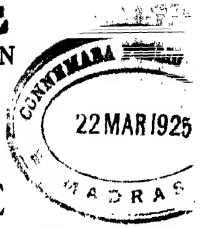

CATALOGUE OF THE COLLECTIONS IN THE SCIENCE MUSEUM

SOUTH KENSINGTON

WITH DESCRIPTIVE AND HISTORICAL NOTES AND ILLUSTRATIONS

LAND TRANSPORT

III. RAILWAY LOCOMOTIVES AND ROLLING STOCK

COMPILED BY

E. A. FORWARD, A.R.C.Sc., M.I.MECH.E.

1923

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PREFACE

The Science Museum, with its Collections and Library, aims at affording illustration and exposition in the fields of mathematical, physical, and chemical science, as well as their applications to astronomy, geophysics, engineering, and to the arts and industries generally. To that end the Museum includes objects which are of historical interest as marking important stages in development, and others which are typical of the applications of science to current practice.

A Museum of Science was contemplated as an integral part of th Science and Art Department from its beginning in 1853, and in 185 collections illustrating foods, animal products, examples of structure and building materials, and educational apparatus, were brough together and placed on exhibition.

The first of the Engineering Collections, that of Marine Construction was formed in 1864, when the Royal School of Naval Architecture was established at South Kensington, and the ship models belonging to the Admiralty were transferred to the Museum from Somerset House, where they had previously been. This collection of ships of war was of great historical interest, and with the assistance of private donors and by purchase it was rapidly increased by the addition of many models of mercantile ships as well as of later ships of war, with the result that when the Admiralty removed their models to the Royal Naval College, Greenwich, in 1873, an important collection still remained at South Kensington. Engineering and Manufactures were first included in 1867, from which time the development of this portion of the Museum advanced steadily; but the transfer of the Museum of the Patent Office to the Department of Science and Art in 1884 added to the collection many machines of the highest interest in the history of invention and greatly increased its scope and value

The collections of scientific instruments and apparatus were first formed in 1874, but it was only after 1876 that they became of importance. The Special Loan Collection of Scientific Apparatus which was held in that year in London brought together examples of all kinds from various countries, and a large number of these were acquired for the Museum.

In 1893, many Mining and Metallurgical objects were transferred to South Kensington from the Museum of Practical Geology in Jermyn Street, and these have subsequently been largely added to.

Mention should be made, too, of certain special Collections. The Watt Collection was presented to the Patent Museum in 1876 and contains original models made by James Watt; the Maudslay Collection, consisting of models of marine engines and machine tools, was purchased in 1900, and in 1903 a valuable collection of engine models, portraits, etc., was bequeathed by Bennet Woodcroft.

The Museum Collections are being continually increased by gifts and loans, and also by the purchase of such examples as are required to illustrate the application of science and the development of various types of instruments, machinery, etc.

Notes.—A large number of objects in the Collections have been photographed. Selected prints from the negatives may be seen in guard books at the entrance stiles. Particulars of available prints and lantern slides may be obtained by personal application at the entrances or by letter addressed " The Director, The Science Museum, South Kensington, S.W.7."

A compressed air service furnishes the power for driving such of the machines as are shown in motion, and the service is available daily from 11 a.m. (Sundays 2.30 p.m) till closing time. Where practicable, these objects are fitted with self-closing air valves, by means of which Visitors may start them at will. Other objects are arranged so that Visitors may work them by other means, and there are a few that can be shown in motion only by an Attendant.

(11289) Wt. P1647/4110B 583 3000 11/23 Harrow G 31

The Land Transport Section of the Collections comprises common roads and road vehicles, railways and tramways with the locomotives and other vehicles used thereon, together with the special appliances necessary for working them The section is divided into four groups each having a separate catalogue

GROUP I. Road Transport.
Includes transport on rough ground or on made roads, animal-hauled vehicles and road construction.

GROUP II. Mechanical Road Vehicles
Includes all mechanically propelled road vehicles and their accessories

GROUP III Locomotives and Rolling Stock
Includes all kinds of railway and tramway locomotives, and vehicles for passengers and goods

GROUP IV Railway Construction and Working
Includes permanent way, structures, stationary engine traction, signalling appliances and operating methods

LAND TRANSPORT.

III. LOCOMOTIVES AND ROLLING STOCK.

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In spite of the fact that the adhesion of smooth wheels on rails had been demonstrated to be sufficient for a locomotive on certain tracks, the idea that something more was necessary was generally held, probably owing to the weakness of the plateways restricting the weight allowable per wheel to an amount that was frequently seen to give insufficient grip. To avoid this difficulty John Blenkinsop, in 1811, patented a form of rack railway (*see* No. 10), which was laid between Middleton and Leeds in 1812, and between Kenton, and Coxlodge and the Tyne in 1813. The engines employed were made by Messrs. Fenton, Murray and Wood, and appear to have been the first commercially successful locomotives; they had two double-acting cylinders, instead of a single cylinder and fly-wheel as generally used by Trevithick, and, although the boilers had only single flues, these engines remained in use until 1835. In 1812 Messrs. W. & E. W. Chapman patented another form of locomotive in which simple adhesion was discarded, the machine propelling itself by toothed wheels, gearing on the upper side with a long chain secured to the ends of the line, this was tried in 1813 at Heaton Colliery, but was soon abandoned

In 1813 William Hedley, assisted by Christopher Blackett, the proprietor of Wylam Colliery, confirmed Trevithick's results as to the possibility of obtaining sufficient grip by adhesion, and, after some experimenting, constructed a locomotive with smooth wheels coupled together by gearing (*see* No 12) The motor portion was an adaptation of the then established form of stationary engine, with vertical cylinders, tappet valve gear, and rocking beams as introduced by Newcomen and retained by Watt

In 1814 George Stephenson constructed for the Killingworth Colliery his first locomotive, named "Blucher," which was a geared engine exhibiting no improvement on the work of his predecessors In his second engine, however, he reintroduced the direct action of the connecting rods on the driving-wheels, as applied by Trevithick in 1808, and used coupling rods for connecting the wheels, although these were subsequently discarded for chain gearing In this way a successful type of colliery locomotive was arrived at, and one which slowly proved its superiority to traction by animals where heavy loads were to be moved at a slow pace

In 1825 the Stockton and Darlington Railway was opened for public traffic, the only engine on the line being, however, "Locomotion" (*see* No. 16) Although intended solely for the conveyance of minerals and goods, the financial success of this, the first public steam railway in the world, was considerably increased by the rapid development of passenger traffic Other engines were soon required for the line, and in 1826 Messrs. Wilson & Co. built one embodying the use of four vertical cylinders. In 1827 Messrs. Stephenson built an engine with two horizontal cylinders connected, by levers and connecting rods, with two cranks at right angles on a single axle, while Hackworth further improved this arrangement in his "Royal George" (*see* No. 20), built later in the same year, by inverting the cylinders and placing them in line with the cranks. In 1828 Stephenson produced the "Lancashire Witch," a locomotive with two inclined cylinders working directly on to one axle, so making another advance towards the now almost universal arrangement of the engine.

The locomotive had not as yet exceeded the speed of the stage coach, while its noise, smoke and jerky motion were defects that rendered it by no means popular, even with the unprejudiced; so

much was this the case that in 1829, when the Liverpool and Manchester Railway was under construction, the directors were still undecided as to the best means of haulage. They offered accordingly a prize of 500*l.* in order to find the best locomotive available and thus be able to compare the new method with stationary engine traction. The results attained by the "Rocket" (*see* Nos. 24 and 25) were such as to settle the question immediately in favour of steam locomotives; this historical engine was moreover the first conveyance that travelled faster than a racehorse, and thus foreshadowed the great future of the railway system

Between 1830–35 the development of the steam locomotive in size and detail was most rapid; the "Northumbrian" of 1830 had a firebox integral with the boiler, and the "Planet" of the same year had inside cylinders at the front end working directly on to a double-cranked rear-driving axle; engines with four and six wheels connected by external coupling rods had been in use since 1825, but the whole arrangement of the locomotive now rapidly settled into the almost universal form, as will be seen in the series of drawings Nos. 18, 41 and 46. The introduction about this period, of improved valve gears led gradually to a reduction in the fuel consumption, but the full advantage of expansive working was not realised till the invention by Howe, in 1842, of the link motion (*see* No 119) which rendered such working both simple and convenient.

The earliest attempt to arrange a locomotive as a compound engine was made about 1849, on the Eastern Counties Railway, when an ordinary goods engine had its valves so altered that the first cylinder cut off at about half stroke and then allowed its steam to expand in both cylinders In 1876 Mons A Mallet introduced compounding on the Bayonne and Biarritz Railway, using one high and one low-pressure cylinder, which could, however, be worked simple if necessary. Mr. F W Webb commenced his work in compounding in 1878, by reducing the diameter of one of the cylinders of an ordinary engine and letting its exhaust pass into the other, while in 1881–82 he built the "Experiment" with two outside high-pressure cylinders driving the hind wheels, and one low-pressure inside cylinder driving the front axle, there being no coupling rods (*see* No 79) In 1897 he introduced his last type in which four cylinders were used, owing to the perfect balancing thus attainable, coupling rods being, however, retained. Mr. A. von Borries built in 1880 some engines on the two-cylinder compound principle for the Hanoverian State Railways, and in 1885 Mr. T. W Worsdell adopted the same arrangement on the Great Eastern Railway and subsequently on the North Eastern Railway (*see* No. 85); as the cylinders were side by side between the frames, the arrangement is one to which existing engines could be easily altered. In 1885 M. de Glehn introduced his four-cylinder compound engine, having two inside high-pressure cylinders driving one axle and two outside low-pressure cylinders driving a separate axle. M. du Bousquet modified this arrangement by interchanging the high and low-pressure cylinders and coupling the driving axles, thus originating the form now so much used on the Continent. In the system patented in 1889 by Mr. S. M. Vauclain of the Baldwin Works, U.S.A., and extensively adopted, there is a high-pressure cylinder and a low-pressure one beneath it, outside the frames on each side; the adjacent piston-rods are secured to a single crosshead, so that additional mechanism is dispensed with (*see* No. 89). In 1898, Mr. W. M. Smith

a gauge of 5 ft., as in use at Wylam till 1808. The arrangement of the engine is almost identical with that in the South Wales engine (*see* No. 1), but the cylinder was at the opposite end to the fireplace. The cylinder is 9 in. diam. by 36 in. stroke, and the boiler 4 ft. diam. by 6·6 ft. long; the road wheels are 38 in. diam., but only revolve at four-fifths of the speed of the crankshaft, so that the tractive factor was 48.

The rougher working drawings are probably from Trevithick's own hand, and amongst other details they show the "Regulating and throttle cocks for the engine" These two plug valves were combined in a single casing, in which the smaller plug served as a regulator for stopping the engine or controlling its speed, while the larger four-way plug was oscillated by a tappet gear so as to place the ends of the cylinder alternately in communication with the steam and exhaust connections, as now done by a slide valve. This locomotive was probably the first one with flanged wheels; it appears, however, to have been only a partial success, probably owing to the wooden rails being unequal to carrying its weight, which was about 4·5 tons Inv. 1873-3 and 28

5. ENGRAVING OF TREVITHICK'S LONDON LOCOMOTIVE (1808) Presented by L. St L Pendred, Esq., M.I.Mech.E., 1921

This print is copied from a water colour drawing by T. Rowlandson which is believed to be a contemporary illustration, although the title and date must have been added later

The engine represented, known as "Catch-me-who-can," ran, between July and September, 1808, on a circular railway in an enclosure on a site near what is now Euston Square No definite particulars of it are known, except that it weighed 8 tons and attained a speed of 12 miles an hour From the imperfect sketch, the engine resembles Trevithick's vertical cylinder stationary engines which he was constructing at that time, but mounted on four wheels with the return connecting rods connected directly with crank pins in the rear wheels Inv 1921-266

6. PORTRAIT OF RICHARD TREVITHICK Woodcroft Bequest, 1903.

This oil painting of Richard Trevithick, born 1771, died 1833, was made by J Linnell in 1816 Inv 1903-108

7. BUST OF RICHARD TREVITHICK Received 1858

This is a plaster bust of Richard Trevithick, 1771-1833, by N N Burnard Inv 1903-109

COLLIERY LOCOMOTIVES.

8. ENGRAVING OF BLENKINSOP'S LOCOMOTIVE (1812) Received 1859

This is from Thomas Gray's "Observations on a General Iron Railway," published in 1821, and it is the best contemporary English representation of these engines

Four were built, in 1812-13, by Messrs Fenton, Murray and Wood, for John Blenkinsop's rack railway between Leeds and the Middleton Colliery, where they worked for about 20 years A full description of them will be found with the Model (No 10) adjacent Inv. 1859-37

9. PHOTOGRAPH OF MODEL OF BLENKINSOP'S LOCOMOTIVE Presented by C. W. Wardle, Esq., 1864.

This is a photograph, made by Messrs Manning Wardle & Co., in September, 1863, of the original model of Blenkinsop's locomotive which is now in the Museum of the Leeds Philosophical and Literary Society. A full description of the engine will be found in connection with the model (No. 10).

Inv. 1864-59. 19263.

10. MODEL OF BLENKINSOP LOCOMOTIVE (working). (Scale 1 : 8.) Made in the Museum, 1910. Plate I, No. 1.

This model represents one of the four engines built by Messrs. Fenton, Murray & Wood, in 1812–13, to work in conjunction with the rack railway patented by John Blenkinsop in 1811, and laid at that time between Leeds and the Middleton Colliery, a distance of 3·5 miles This enterprise was the first in which the steam locomotive was used with financially successful results; the engines remained at work for about 20 years It is recorded that similar engines were used also on three other colliery railways. The rack railway has, moreover, survived, and is extensively adopted for mountain lines with exceptionally steep gradients.

The arrangement of the engine was an improvement on those built by Trevithick, although obviously based on them, in having, at the suggestion of Matthew Murray, two cylinders working on separate shafts so connected that the cranks remained at right angles, thus avoiding any difficulty in starting. There is reason to believe, however, from the contemporary records upon which this model is based, that the design did not arrive at once at its final shape.

The engine had a cast-iron boiler of oval section 37 in. by 32 in. and 9·6 ft. long, made in two parts bolted together, and having a single furnace flue 14 in diam. passing through it; in the boiler on the centre line were sunk, for one half their length, two vertical cylinders, 9 in. diam. by 22 in. stroke, exhausting directly into the atmosphere. Each piston-rod was controlled by two vertical guides, while by a pair of return connecting rods it drove parallel outside cranks on a crankshaft below it. These two crankshafts were connected through gearing with an intermediate shaft, upon one end of which was a large spur wheel gearing with the teeth of the rack rails The steam distributing valves were four-way plug cocks oscillated through 90 deg. by wrist plates, which were connected by horizontal rods above the boiler, with vertical levers pivoted near the centres of the boiler ends; these levers extended an equal distance downwards, and their lower ends were connected with eccentrics mounted on the crankshafts Reversing was effected by making the cocks oscillate through an angle of 90 deg. adjacent to the angle used for forward motion, and this was done by attaching the valve rods to points in the wrist plates at right angles to the former ones. Short levers, having the valve rods attached to their lower ends, were mounted loosely on the valve stems, and pins in their upper ends engaged with either of two holes in the wrist plates Forked hand-levers, engaging with collars on the valve lever bosses, were provided for sliding them into and out of gear Two smaller plug cocks, coupled by a rod, controlled the steam supply from the boiler A direct loaded spring safety valve was fitted at each end of the boiler shell. The boiler and gearing were supported by a wooden frame carried upon four wheels 35 in diam, with a wheel base of 7·33 ft., the driving spur wheel was 38·2 in pitch diam, and revolved at one half the speed of the crankshafts, so that the tractive factor was 93·6 The boiler was fed by a pump, immersed in a water tank carried at the front end of the engine, and driven by the valve gear The fuel was carried on a platform between the frame beams, at the rear of which the driver stood, so that no tender was required. The boiler and cylinders were lagged entirely with wood

Blenkinsop stated that one of these engines weighed 5 tons, and cost 400*l.*, and that it did the work of 16 horses in 12 hours It drew 27 wagons, representing a load of 94 tons, at 3·5 miles an hour on the level, or 15 tons up a gradient of 1 in 18, lightly loaded its speed was 10 miles an hour. The consumption of coal was 21·3 lb, and of water 14·3 gal. per train mile, so that each pound of coal evaporated 6·7 lb of water.

The track consisted of cast-iron edge rails each 3 ft long. On one side of the track the rails had cast with them six teeth of 6 in. pitch projecting from their outer sides. The rails were held in special chairs by wooden keys, while the chairs were spiked to wooden cross sleepers. The gauge of the rails was 4·12 ft.

Inv. 1910–21. S.M. 214

11. HEDLEY'S EXPERIMENTAL MODEL FOR TESTING ADHESION. Presented by Thomas Hedley, Esq., 1862.

Christopher Blackett, the proprietor of Wylam Colliery, had since 1804 been in search of some means of haulage better than animal power for conveying coal wagons over the 5 miles of track between his colliery and the wharves on the Tyne. He had found that Trevithick's locomotive did not succeed on his wooden rails, and, the then generally accepted explanation being that the

smooth wheels gave insufficient grip, no further experiments were made in mechanical traction till 1811. In that year William Hedley, the viewer of Wylam, constructed the model shown, which has four road-wheels secured to two axles, geared together by intermediate spur wheels, and capable of being rotated by external winch handles.

The results he obtained from the model led to the construction of a full-sized under-frame, with wheels similarly connected by gearing, and worked by men carried on it, so that the adhesion of all of the coupled wheels was available for tractive effort; this frame was subsequently fitted with a cast-iron boiler and a single steam cylinder 6 in. diam., which drove the road-wheels through intermediate gearing. After repeated trials with this experimental engine the construction of an entirely new one was decided upon chiefly because of the defective steaming capacity of the boiler Inv 1862–4. 19258.

12. "PUFFING BILLY" LOCOMOTIVE. Received 1865. Plate I, No. 2.

This engine was constructed at Wylam Colliery in 1813 by William Hedley, assisted by Jonathan Foster and Timothy Hackworth, who subsequently became locomotive superintendent of the Stockton and Darlington Railway It worked between the colliery and the staithes at Lemington-on-Tyne

The engine has two vertical steam-jacketed cylinders 9 in diam by 36 in. stroke, which, by grasshopper beams, transmit the power downward by connecting rods to a shaft with overhanging cranks set at right angles This shaft carries a spur wheel, which, by four other spur wheels, transmits the power to the four driving-wheels, each 39 in diam, giving a tractive factor of 40, although originally the gearing made this factor 80 Steam is distributed by slide valves worked by a tappet motion, and the places for the driver and fireman are at opposite ends of the boiler

The boiler is a wrought iron cylinder with one egg end, and has an internal return furnace flue, as used by Trevithick, the grate area is 6 sq ft, the heating surface 77 sq ft, and the steam pressure was 50 lb per sq in The engine weighed 8·3 tons in working order, and usually hauled about 50 tons at a speed of 5 miles an hour. The tender consists of a wooden frame, supported on four wheels, carrying a water tank and coal box, it weighed 4·3 tons when loaded.

Owing to the weakness of the plate-way, which was of cast iron, the engine was in 1815 rebuilt as an eight-wheeler, each group of four wheels being carried in a kind of bogie, and two more wheels introduced into the gearing It was altered back to four wheels about 1830 when the line was relaid with the cast iron edge rails now seen under it These rails are of the double-flanged fish-bellied type, with half-lap joints supported in chairs spiked to cross sleepers, and with a gauge of 5 ft, each rail is 4 ft long, and weighs 52 lb

When first introduced the noise and smoke from these locomotives caused considerable irritation, so that legal opinion was taken on the subject (*see* adjacent frames), but the nuisance was subsequently abated by passing the exhaust steam into a quieting chamber before discharging it into the chimney
Inv 1862–2, 119 13561, 3 and 23557

13. PHOTOGRAPHS OF "PUFFING BILLY." Received 1898.

These show "Puffing Billy" at work in 1862, prior to its removal to South Kensington, and also the sister engine "Wylam Dilly" which worked until 1867, and is now preserved at the Edinburgh Museum of Science and Art
Inv 1898–40

14. DRAWINGS OF "PUFFING BILLY" LOCOMOTIVE (1813). (Scale 1 : 8) Made by Thos Coates, 1892.

These are dimensioned working drawings of the engine as it now stands
Inv 1892–186.

15. AUTOGRAPH LETTER FROM WILLIAM BRUNTON (1813). Presented by J. L. Brunton, Esq., 1922.

This letter, dated April 28th, 1813, is from William Brunton to his brother John, giving a description of his steam horse Patent No 3700–1813.
Inv. 1922–248.

16. MODEL OF "LOCOMOTION," ENGINE NO. 1 OF THE STOCKTON AND DARLINGTON RAILWAY. (Scale 1 : 8.) Presented by Sir David Dale, Bart., 1896. Plate II, No. 1.

The engine represented was built by Messrs. R. Stephenson & Co. in 1825, and ceased running in 1846, but is still preserved in working condition at Darlington by the North Eastern Railway Co.

The engine has two vertical cylinders 10 in. diam. (originally 9·5 in.) by 24 in stroke, each driving by side connecting rods a pair of 48 in. diam. driving wheels These wheels are of cast iron and are coupled together by external rods that maintain the driving crank-pins of the front and rear wheels at right angles The valves are of the ordinary type, driven by rocking shafts which both receive their motion from a single eccentric on the leading axle, one shaft being rocked directly, and the other through a bell-crank lever. A platform runs along each side of the boiler, and from one of these the driver has control of the valve rods, for disengaging and reversing The tractive power of this engine per lb. of mean pressure in the cylinders was 50 lb., and the boiler pressure used was 50 lb. per sq in. The exhaust steam from both cylinders was conveyed by two pipes into the chimney. The feed water was forced into the boiler by a single feed-pump 4 in diam., driven by a lever from the front crosshead

The boiler is 10 ft. long by 4 ft diam., and has a single through flue 24 in. diam. and 10 ft in length, delivering into the chimney, which is 15 in. diam., the heating surface is about 60 sq ft The wheel base of the engine is 5·17 ft., and the weight in working order is 6·5 tons A single safety valve is provided, loaded by a weighted lever

The tender is built of timber, holds 15 cwt. of coal, and carries an iron tank containing 240 gal of water The tender, which also acts as a platform for the fireman, is carried on four cast iron wheels 30 in. diam., has a wheel base of 4·75 ft, and when empty weighs 1·25 tons

"Locomotion" is estimated to have been of about 10 h.p., and had a speed of 8 miles an hour The total weight of engine and tender in working order was about 9·75 tons

The model is shown supported upon a model of the first railway bridge constructed by George Stephenson; it was erected at West Auckland in 1824, and was only replaced in 1901. The rails are of wrought iron, rolled to the fish-belly form and supported in chairs, which are shown resting on the timber-flooring of the bridge Inv. 1896–88 and 89. 19378 and 31073.

17. PHOTOGRAPH OF "LOCOMOTION" AND A N.E.R. LOCOMOTIVE. Presented by Messrs. R. Stephenson & Co., Ltd., 1911.

This shows "Locomotion" of 1825 standing beside a 6-coupled North Eastern Railway goods engine of 1909, and the comparison gives a good idea of the increase in size during the intervening 84 years Inv 1911–5.

18. DRAWING OF EARLY LOCOMOTIVES BUILT BY MESSRS. ROBERT STEPHENSON & CO (1825–51.) (Scale 1 : 24) Prepared chiefly from tracings and particulars furnished by C. E. Stretton, Esq., 1898.

The Forth Street works at Newcastle, on the north bank of the Tyne, were established in 1823 by Messrs George Stephenson, Robert Stephenson, Edward Pease, and Michael Longridge. The first order was received in 1824 for two engines for the Hetton Colliery Co, these were of the same size and construction as the first engine represented on the sheet.

No. 3 was built in 1825, and is the famous No 1 engine of the Stockton and Darlington Railway. It is now preserved at Bank Top, Darlington (*see* No 16)

No. 12 was built in 1828, and delivered in January, 1829, to an American canal company. It was a four-wheeled engine, with coupled wheels 4 ft. diam., and two outside inclined cylinders 9 in. diam. by 24 in. stroke.

No. 19 was the famous "Rocket" (*see* No. 24), built in 1829, to the joint order of George and Robert Stephenson

No. 20 was delivered in 1830 to the Canterbury and Whitstable Railway, now a portion of the South Eastern system. The boiler was subsequently lengthened, and in this condition the engine is still preserved (*see* No. 42.)

It had four coupled wheels 4 ft. diam., driven by two outside inclined cylinders 10 in. diam. by 18 in. stroke, giving a tractive factor of 37. The boiler, which is subsequent to that of the "Rocket," had 25 tubes 3 in. diam. and a rectangular firebox. An important feature in this engine is that the cylinders are at the forward end, an arrangement that has since been almost universally followed.

No. 29, delivered in October, 1830, to the Stockton and Darlington Railway, was a four-wheeled coupled engine, with two inside cylinders, 11 in. diam. by 16 in. stroke, placed beneath the smokebox. The wheels were 5 ft. diam., and the total heating surface was 407 sq. ft.

In 1830–31 a new set of books was opened. The 37 locomotives already built are not included in the new books, which started with a fresh No. 1, that formed part of an order for three engines for the Stockton and Darlington Railway. The following numbers must therefore be increased by 37 to give their true position in the output of the Forth Street works.

No. 25 was delivered in America in May, 1831. It is a four-wheeled coupled engine, with inside cylinders 9 in. diam. by 20 in. stroke, and wheels 4·5 ft. diam. The firebox is circular in plan. This engine was renamed "John Bull," and is still preserved in the National Museum at Washington.

No. 42 was delivered in America in April, 1833, it had a single pair of driving wheels at the back, 4·5 ft. diam. driven by two inside cylinders 9 in. diam. by 14 in. stroke. The front end of the engine was carried on a four-wheeled bogie.

The standard goods engines, built 1835–37, had inside cylinders 15 in. diam., 18 in. stroke, driving four coupled wheels 4·5 ft. diam., and there was a leading pair of smaller wheels, previously these additional wheels had been arranged on a trailing axle. The total heating surface was 571 sq. ft., the tractive factor was 75, and the weight of the engine in working order without tender 14·6 tons.

No. 150, "North Star," was delivered in 1837 to the Great Western Railway, and is famous as the first engine of that line, although not originally designed for it, the link motion shown was added subsequently. It had a pair of inside cylinders 16 in. diam. by 18 in. stroke, and single driving wheels 7 ft. diam., giving a tractive factor of 55. The heating surface was 850 sq. ft. and the grate area 11·76 sq. ft.

The engine "Folkestone," delivered to the South Eastern Railway Co. in 1851, was constructed to a design by Mr. T. R. Crampton, and had a single driving axle behind the firebox with wheels 6 ft. diam., while the front four wheels were 3·5 ft. diam. There was a pair of cylinders 15 in. diam. by 22 in. stroke, arranged under the smokebox and working on a crankshaft, from which, by outside cranks and coupling-rods, the motion was transmitted to the driving wheels. Several of these engines were built, and they attained high speeds, but in general work the arrangement was not satisfactory, they were afterwards all converted to the ordinary form with wheels upon the driving axles.

Inv. 1898–78. 18323.

19. DRAWINGS OF EARLY LOCOMOTIVES EMPLOYED ON THE STOCKTON AND DARLINGTON RAILWAY (1825–62)

(Scale 1·24.) Prepared from tracings and particulars presented by C. E. Stretton, Esq., 1901.

The Stockton and Darlington—the first public steam railway in the world—was originally projected in 1817 by Edward Pease of Darlington, chiefly for the conveyance of coal from the Bishop Auckland collieries to the sea-board. The Bill authorising its construction, after being twice rejected, was passed in 1821, it provided for its being worked "by men and horses, or otherwise." In 1822 the line was re-surveyed and construction commenced, but in the following year, at the advice of George Stephenson, who made the final survey and had been appointed the engineer, a fresh Act was obtained, giving power to carry passengers as well as goods, and to employ locomotive engines.

The line commenced on the north bank of the Tees at Stockton, and proceeded in a westerly direction to Darlington and thence to the north-west terminus at Bishop Auckland, a distance of 24·66 miles, but there were four branches which brought up the total length to 36·25 miles, as shown on an adjacent ordnance map. The line was single, with passing places every quarter-mile, wrought iron fish-bellied rails weighing 28 lb. per yard were used, and the gauge was 4 ft. 8 in., but more clearance being required, this was increased by 0·25 in. in 1840, and soon afterwards to the present standard. The cost per mile was about 9,000*l.*, and the ruling gradient was 1 in 104, but at Brusselton and Etherley there were inclines of nearly 1 in 33 which were worked by stationary engines.

The first rail was laid at Stockton in May, 1822, and the line was opened for traffic on September 27th, 1825, by the engine "Locomotion," driven by George Stephenson and drawing a train of 34 vehicles forming a gross load of over 90 tons. The first regular passenger coach, the "Experiment," was put on in October, 1825, from which time both goods and passenger traffic rapidly increased; the identity of the undertaking became lost in 1863, owing to its being absorbed into the North Eastern Railway system. Reproductions of an advertisement and of a way-bill of the original line are shown in an adjacent section.

In the drawing the following 10 of the early engines employed are represented, while a table gives particulars of their dimensions:—

No. 1, "Locomotion," was built in 1825 by Messrs. R. Stephenson & Co. This engine is fully described in connection with its model, No. 16; three similar engines, named "Hope," "Black Diamond" and "Diligence," were constructed for this line in 1826.

No. 5, "Stockton," built by Messrs. R. Wilson & Co. of Newcastle in 1826, is said to have had four vertical cylinders 6 in. diam. by 18 in. stroke with crossheads sliding in guides and each working, by a return connecting rod, a driving wheel 48 in. diam., thus having a tractive factor of 27. This engine was unsatisfactory and, having been damaged in collision, portions of it were used in building the "Royal George" (*see* No. 20).

No. 5, re-named "Royal George." This engine was constructed at Shildon Works in 1827 by T. Hackworth, who utilised the boiler and wheels of the "Stockton," but provided two new vertical cylinders with valve motions, and an additional pair of driving wheels. Further particulars of this engine are given in connection with its model, No. 20.

No. 9, "Globe," designed by T. Hackworth and built by Messrs. R. Stephenson & Co. in 1830, had horizontal inside cylinders, 11 in. diam. by 16 in. stroke, placed under the furnace, and four coupled driving wheels 60 in. diam., thus having a tractive factor of 32. The boiler was 10 ft. long by 3 ft. diam. and had a single flue with the grate in one end; on the top of the shell was a copper steam vessel in the form of a globe, from which the engine received its name. This locomotive ran till 1839, when its boiler exploded.

No. 13, "Coronation," designed by T. Hackworth and built by Messrs. R. and W. Hawthorn in 1831, was one of 13 engines built for mineral traffic; it had two vertical cylinders, 14·5 in. diam. by 16 in. stroke, overhanging at the front and driving, through an intermediate shaft, 6 coupled wheels 48 in. diam., thus having a tractive factor of 70. The boiler was 13 ft. long by 43 in. diam., and had one furnace tube 9 ft. long and 106 small tubes 4 ft. long.

No. 26, "Swift," designed by T. Hackworth and built by Messrs. R. and W. Hawthorn in 1836, had two vertical cylinders 11 in. diam. by 16 in. stroke working, through an intermediate shaft, the driving wheels, which were 48 in. diam., thus having a tractive factor of 40. The boiler was 9·6 ft. long and of oval section, 3 ft. wide by 4 ft. high, it contained a fire tube 4·6 ft. long, 29 in. diam., and 102 tubes 5 ft. long, its total heating surface was 256 sq. ft.

No. 27, "Arrow," built by T. Hackworth at Shildon in 1837, had inside cylinders 22 in. diam. by 9 in. stroke which, by rocking levers, drove cranks of 18 in. throw in the driving axle. The pair of driving wheels were 60 in. diam., giving a tractive factor of 72, and there were four other wheels 36 in. diam. The boiler had a rectangular firebox of copper, and there were 133 tubes.

No. 43, "Sunbeam," designed by T. Hackworth and built by Messrs. R. and W. Hawthorn in 1837, was a four-wheeled engine with single drivers 60 in. diam. and horizontal inside cylinders 12 in. diam. by 18 in. stroke, giving a tractive factor of 43. It remained in use on passenger traffic till 1856.

No. 165, "Keswick," built by Messrs. R. Stephenson & Co. in 1862, was a large passenger engine with a leading bogie and four coupled wheels 84·5 in. diam., the cylinders were outside and 16 in. diam. by 24 in. stroke, thus giving a tractive factor of 73. The boiler had 1,053 sq. ft. of heating surface, 12·75 sq. ft. of grate area, and there was a feed-water heating tank under the footplate.

Inv. 1901–125. 24164.

20. ORIGINAL MODEL OF THE LOCOMOTIVE "ROYAL GEORGE" (1827). (Scale 1 : 16) Received 1898. Plate II, No. 2.

The "Stockton" was No. 5 locomotive on the Stockton and Darlington Railway, and was built in 1826 (*see* No. 19). The engine, however, proven so unsatisfactory that in 1827 Timothy Hackworth, the locomotive superintendent of the railway, obtained permission to rebuild it, and this model

represents the reconstructed engine known as the "Royal George," which worked on the line from 1827 till 1842. The model shown was probably made to prove to the directors of the Stockton and Darlington Railway the soundness of Hackworth's design for the reconstruction of their original No. 5 engine.

Using the original boiler shell, which was 4·33 ft. diam. by 13 ft. long, Hackworth increased the heating surface by introducing into it the return flue of Trevithick (*see* No. 1), and as seen in Hedley's "Puffing Billy" (*see* No. 12); the wheels he increased to six in number, all coupled, while he used only two cylinders, 11 in diam. by 20 in stroke, arranged vertically over the trailing wheels. The load on the other wheels was distributed by long plates arranged as equalising levers.

The piston rods are guided by parallel motions, by the levers of which a valve shaft is continuously rotated; on this shaft are two loose eccentrics that form a valve motion and reversing gear.

The tractive power per lb of mean steam pressure was 50 lb, and the weight of the engine and tender was 15 tons; it could draw on the level thirty-two coal wagons weighing 130 tons at a speed of 5 miles an hour Inv 1898–48 21453.

21. ORIGINAL DRAWINGS OF EARLY LOCOMOTIVES. Lent by Messrs. Robert Stephenson & Co., Ltd., 1901.

These are original working drawings of some of the locomotives built by this firm between 1828–34, for the Liverpool and Manchester and other railways. They include drawings of "Invicta," "Northumbrian," "Planet," "Patentee," and of link motion details, 1842, each has a short description attached. Inv 1901–16.

22. THE "AGENORIA" LOCOMOTIVE (1829). Presented by W. O. Foster, Esq., 1884.

This engine was built by Messrs Foster, Rastrick & Co., of Stourbridge, for the Shutt End colliery railway at Kingswinford, Staffordshire, which it opened in June, 1829, and afterwards worked over for more than thirty-five years, it is almost identical with the "Stourbridge Lion," built by the same firm in 1828, and sent to America, where it was the first locomotive to run upon rails on that continent

The engine has four coupled wheels, 48·75 in diam., with a wheel base of 5·08 ft, and two vertical cylinders 8·5 in. diam by 36 in stroke, driving outside crankpins set at right angles to one another and fixed in the rear wheels; the tractive factor is 53·4 The crossheads are guided by grasshopper parallel motions, and the connecting rods are attached to intermediate points of the beams directly in front of the cylinders, thus reducing the crank throw to 27 in. The slide valves, of the common flat type, are driven by loose eccentrics whose motion is controlled by stops, fixed to the axle, which retain them in the correct positions for forward or backward motion; hand gear is provided for working the valves when reversing, and until the eccentrics attain their positions against the stops.

The boiler consists of a cylindrical barrel 4 ft diam and 10 ft. long formed with dished ends. The grate is contained in a furnace tube 29 in diam, which branches into two flues, each 18 in diam., through which the heated gases pass to a chamber at the forward end; this chamber is completely within the shell and it communicates with the chimney by a short vertical tube passing through the upper part of the barrel. The back end plate carries the furnace and flues and is attached to the barrel by bolts, thus enabling the whole of the internal portion of the boiler to be easily removed for cleaning or repairs The boiler is fitted with a dome surmounted by a spring-loaded safety valve and was originally provided, in addition, with a "lock-up" safety valve; a single feed pump is provided which is driven from one of the grasshopper beams. The exhaust steam is turned into the chimney, but, from the exceptional height of the latter, it is probable that this blast was not utilised to increase the draught; at the time the engine was built, great objections were raised to the noise of locomotives, and also to the smoke given off; these annoyances would be reduced by a quiet exhaust and a tall chimney. The grate area is 8·5 sq. ft., and the heating surface about 85 sq. ft

The engine frames are of wood flitched with iron plates, which form also the axlebox guides; the boiler is secured to the frames at each end, while the cylinders and gear are fixed solely to the boiler. Springs are fitted to the front axleboxes only, as the action of the vertical connecting rods would have

prevented their use over the rear axle; the axleboxes were provided with mechanical lubricators, driven by toothed rings on the axles. The wheels are of cast iron with wrought iron tires, and the trailing pair are fitted with balance weights. The engine and tender in working order weighed 11 tons.

The engine is standing on some of the rails and chairs from the Shutt End line. Inv. 1884–92. 23555.

23. DRAWINGS OF "AGENORIA" LOCOMOTIVE (1829). (Scale 1 : 8.) Made by Thos. Coates, 1892 and 1893.

These are dimensioned working drawings of the engine as it now stands. Inv. 1892–190 and 1893–251.

RAINHILL TRIALS.

24. THE "ROCKET" LOCOMOTIVE (1829). Presented by Messrs. Thompson & Sons, 1862 Plate III, No. 1.

This celebrated engine was constructed by Messrs R. Stephenson & Co in 1829, to compete for the 500*l* prize offered by the directors of the Liverpool and Manchester Railway to the makers of the most successful locomotive competing at a trial to be held at Rainhill in October of that year; the particulars and conditions of the trial are given in No 39

The "Rocket" left Newcastle on September 12th, 1829, going part of the way by canal, and was delivered by wagon at Rainhill on October 2nd; the competition commenced on October 6th and continued for eight days. At that time the "Rocket" was painted yellow, relieved with black, while the chimney was white Her greatest speed was 29 miles an hour; some years afterwards, however, she ran four miles in 4·5 minutes, or at the rate of 53 miles an hour After the trial the "Rocket" was purchased by the Liverpool and Manchester Railway Co, and worked on the cutting between Chat Moss and Salford till the opening of the line on September 15th, 1830, during this period, however, the engine was improved by the addition of a smokebox and the chimney was shortened At the ceremony of opening the railway, this engine ran over and fatally injured the Right Hon. William Huskisson, then M.P. for Liverpool, this sad accident, however, drew great attention to the possibilities of travelling by steam, as George Stephenson took the injured gentleman to his destination, 11 miles away, at a speed of 36 miles an hour The "Rocket" worked on the Liverpool and Manchester line till 1836, when it was removed to the Midgeholme Railway, near Carlisle, where it ceased running in 1844, it was brought to South Kensington in 1862

The engine as it now exists differs in several respects from its form in 1829, the present steam and exhaust pipes, the chimney and the dummy wooden connecting rods were fitted in 1862, the cylinders were originally arranged at an inclination of 35 deg with the horizontal, but they were altered within a year or two to their present inclination of 8 deg, the present trailing wheels are quite modern, but the original wheels, which were also of cast iron, were 30 in diam

The engine has two cylinders, 8 in diam by 17 in stroke, directly acting on driving wheels 56 5 in diam, thus having a tractive power of 19·4 lb. per lb of mean steam pressure The slide valves are worked by loose eccentrics, and there is a clutch arrangement, worked by a treadle, by which these eccentrics could be thrown out of gear when the engine was to be reversed, the valves at the time being independently worked by hand levers The boiler has a cylindrical barrel 3 ft 4 in. diam by 6 ft long, which was traversed by twenty-five copper tubes 3 in diam. The firebox was of copper, and was bolted on to the end of the barrel, it had at the top, back, and sides a 2·5 in. water space The gases from the firebox passed through the tubes into a small chamber at the base of the chimney, which served as a smokebox; the area of the grate was 6 sq ft, and the heating surface of the firebox 20 sq. ft.; owing to the introduction of the boiler tubes, the total heating surface was 138 sq ft. Two copper pipes, 2·5 in. diam, connected the water space of the firebox with that of the barrel, and two similar pipes placed at the top of the firebox placed it in communication with the steam space of the barrel. The steam from the boiler was admitted to the cylinders by two copper pipes, leading from a regulating cock fixed above the firebox and which received steam from a dome above the

barrel through an internal pipe The boiler pressure was limited to 50 lb. by two safety-valves 2·5 in. diam., one of which was loaded by a spring and lever, while the other was of the lock-up type covered by a dome of tin plate. The feed-water was introduced by a long-stroke pump worked directly from the crosshead, while the exhaust steam was passed into the chimney by two pipes each fitted with a nozzle 1·5 in diam., by which a draught equivalent to 3 in. of water pressure was ultimately obtained

The framing of the engine is built up of 4 in. by 1 in. bar iron, and the weight is transmitted to the axleboxes by plate springs. The engine weighed, when empty, 3·25 tons, and in working trim 4·25 tons, while the tender, which was a four-wheeled truck carrying a water barrel, weighed, when loaded, 3·2 tons, so that the total weight of the engine and tender in working condition was 7·45 tons The wheel base was 7 ft 2 in

The engine is now standing on some of the original wrought iron rails of the Liverpool and Manchester line, presented by Mr C. E Stretton, in 1892
Inv. 1862–5. 23556.

25. MODEL OF "ROCKET" LOCOMOTIVE AND TENDER (working). (Scale 1 8) Made from drawings prepared in the Museum, 1909 Plate III, No. 2

This model, which is partly in section, represents the famous locomotive "Rocket" as originally built for the Rainhill trials in 1829 (*see* Nos 24 and 40). It is in general accordance with the known records and relics, but although a great deal of information on its construction has been preserved there are some points of detail upon which uncertainty exists

The engine ran on four wheels and had two cylinders, 8 in diam by 17 in. stroke, placed at the rear end of the boiler and inclined downwards at 35 deg with the horizontal, the piston rods drove the front wheels, which were 56·5 in diam, thus giving a tractive factor of 19·4 The trailing wheels were 30 in diam. and the wheel base 7·17 ft. The cylinders were mounted on iron plates, which were bolted to the boiler shell and supported by stays, these plates also carried the guide bars, which were of square section, set diagonally, while the crossheads were of brass, in halves, bolted together and embracing the bars. The steam chests were below the cylinders and the slide valves were driven, through an intermediate shaft and levers, by a pair of eccentrics fixed to a loose sleeve which could be moved endwise along the shaft by a pedal so as to engage with either of two drivers, one set for forward and the other for backward running The valve rods had gab ends, so that the valves could be disengaged and worked by hand levers when reversing The crankpins had spherical ends, to allow for irregular motion of the engine relative to the driving axle

The boiler was a cylindrical shell, 40 in diam by 6 ft long, made in two rings, with a circumferential lap joint and longitudinal butt joints, the flat ends were secured by angle rings and tied together by longitudinal stays The shell was traversed by twenty-five copper tubes, 3 in. diam., secured in holes through the end plates The firebox shown is supposed to be the original design, but it is not certain how soon it was altered in shape It was a separate chamber of copper bolted on to the back end of the barrel It was rectangular in plan, with a sloping back in which was the fire-door, there were water spaces at the top, back and sides, while there was a firebrick lining in front, below the tubes Copper pipes connected the water and steam spaces of the firebox with those of the barrel The total heating surface of the boiler was 138 sq. ft., that of the firebox being 20 sq ft, the grate area was 6 sq ft The chimney was nearly 15 ft. high, above the rails, and was swelled out at the base to cover the tube ends; it was supported by stays from the cylinder plates

Steam from the boiler was admitted to the cylinders by two pipes leading from a regulating cock fixed above the firebox and which received steam from a dome through an internal pipe. The boiler pressure was limited to 50 lb per sq in by two safety valves, one of which was loaded by a spring and lever, while the other was a lock-up valve covered by a small dome. A mercurial gauge was fitted beside the chimney and was arranged to indicate the steam pressure from 45 to 60 lb.; a water gauge was fitted behind one of the cylinders and two gauge cocks near the front end of the boiler. The feed water was introduced by a long stroke feed pump worked from one crosshead, while the exhaust steam was passed into the chimney by two pipes, each fitted with a brass nozzle 1·5 in. diam.

The framing of the engine was wholly between the wheels, and was built up of flat bar iron bent down at the rear end to accommodate the firebox and rear axle; to this the cast-iron axlebox guides were secured, and four brackets to support the boiler. The weight was transmitted to the axles by plate springs. The driving wheels were constructed with cast iron bosses, in which the crank-pins were fixed, oaken spokes and felloes, and iron tires secured by bolts The engine weighed 3·25 tons when empty and 4·25 tons in working order

The tender was a four-wheeled wooden truck carrying the fuel in the body and the water in a large barrel above it The axles had outside bearings and plate springs, the wheels were 36 in diam and the wheel base was 4 ft. It weighed 3·2 tons when loaded, so that the total weight of engine and tender in working order was 7·45 tons Inv. 1909–3 S M. 6, 7 and 8.

26. DRAWINGS OF THE "ROCKET" LOCOMOTIVE (1829). (Scale 1 : 8) Made by Thos. Coates, 1892.

These are dimensioned working drawings of the engine as it now stands. Inv 1892–187.

27. PORTRAIT OF GEORGE STEPHENSON. Presented by Sir H. F. Wilson, K.C.M G, 1920

This is a pencil drawing of George Stephenson by H P. after a painting by Briggs R A 1838 Inv 1920–477.

28. PORTRAIT OF GEORGE STEPHENSON. Woodcroft Bequest, 1903

This is a mezzotint engraving of George Stephenson, born 1781, died 1848. It was engraved by T S Atkinson after a painting by John Lucas Inv 1903–106

29. RELICS OF GEORGE STEPHENSON. Presented by G. A Mosse, Esq.

These objects were the personal possessions of George Stephenson, the celebrated locomotive and railway engineer (1781–1848) They comprise watches, measuring and drawing instruments, toilet articles, etc Inv 1875–3.

30. PORTRAIT OF ROBERT STEPHENSON. Woodcroft Bequest, 1903

This is an engraving of Robert Stephenson, born 1803, died 1859 It was engraved by J R Jackson after a painting by John Lucas, and published in 1846 Inv 1903–107

31. THE "SANS PAREIL" LOCOMOTIVE (1829). Presented by John Hick, Esq, 1864. Plate IV, No. 1.

This locomotive was made by Timothy Hackworth, the engine superintendent of the Stockton and Darlington line, to take part in the Rainhill competition in October, 1829, where, however, it proved unequal to the "Rocket," although in some respects it was a well-built engine After the trial, however, the engine was purchased by the Liverpool and Manchester Railway Co, and used until 1831, when it was transferred to the Bolton and Leigh Railway In 1837 the present cylinders, which are larger than the original ones, were substituted and the wood-spoked wheels were replaced by wheels of cast iron In 1844 it was removed to Coppull Colliery, near Chorley, where one axle and a pair of wheels were removed, and toothed gearing fitted to the other axle, in order to give motion to pumping and winding machinery It worked in this way most satisfactorily till 1863, when, on the mine being exhausted, the engine was re-erected as a locomotive and presented to the Museum.

The boiler has a cylindrical shell, 4·33 ft. in diam. and 6·1 ft. long, with one end flat and the other dished; this contains and internal flue, 15 in. in diam., which projects beyond the boiler on the fire grate side, and is enclosed in a water-jacket, thus considerably increasing the grate and heating surfaces. There are two vertical cylinders acting directly downward on crankpins in the

driving wheels, which are, however, connected by coupling rods with the trailing wheels, and the engine is without springs. The valves are worked by two loose eccentrics on the driving axle, driven by a clutch in one direction or by another clutch in the other direction when the engine is reversed, there being hand gear to control the valves when reversing in a similar way to that sometimes adopted in early marine engines The exhaust steam was discharged into the funnel as a powerful blast, and, with the large flue employed, carried over much unconsumed fuel

The cylinders were 7 in diam and 18 in. stroke, acting on four coupled wheels 4·5 ft. diam , giving a tractive power of 16·3 lb. per lb. of mean steam pressure. The boiler had a grate area of 10 sq ft. and a total heating surface of 90·3 sq ft The engine in working trim weighed 4·77 tons; the tender was similar to that of the " Rocket "

The " Sans Pareil," as in the case of the " Rocket," is now standing on some of the original Liverpool and Manchester rails, with stone sleepers, which are 24 in. square and 10 in deep. Inv 1864-45 23554.

32. DRAWING OF THE "SANS PAREIL" LOCOMOTIVE (1829). (Scale 1 . 6) Presented by John Hick, Esq., 1864.

This is a copy of an original drawing showing the " Sans Pareil " as first built. Inv. 1864-70.

33. DRAWINGS OF THE "SANS PAREIL" LOCOMOTIVE (1829). (Scale 1 8) Made by Thos Coates, 1892

These are dimensioned working drawings of the engine as it now stands Inv 1892-188.

34. PORTRAIT OF TIMOTHY HACKWORTH. Made in the Museum, 1922

This is a photograph from an oil painting of Timothy Hackworth (1786-1850), the first locomotive engineer of the Stockton and Darlington Railway The original is in the possession of Robert Young, Esq , but its date and the name of the artist are unknown Inv 1922-753

35. PORTIONS OF THE " NOVELTY " LOCOMOTIVE (1829). Presented by the Rainhill Gas and Water Co., 1904 Wheels received 1914.

The " Novelty " was built in 1829 in the short space of seven weeks by Messrs J Braithwaite and J Ericsson to compete at Rainhill for the 500*l* prize offered by the Liverpool and Manchester Railway Co During the trials it excited much interest; it attained a speed of 31·9 miles per hour when running light, but owing to breakdowns was unable to fulfil the required tests and was, therefore, withdrawn from the competition The engine was afterwards run experimentally on the line for some time, and in 1833 it was provided with new cylinders and boiler tubes by Mr R Daglish , it was used on the North Union Railway during its construction in 1838, after which its history is unknown The original cylinders were, however, given to Mr John Melling, who founded the engineering works at Rainhill, now occupied by the Gas and Water Co , where they remained in partial use until this one was presented to the Museum

The parts exhibited are One complete cylinder with its crosshead and guide bars, the pedestal, the two side rods which connected the crosshead with the bellcranks, part of the valve gear, and the wheels The cylinder is 6 in. diam by 12 in stroke, and stands on a small table which forms the bottom cover; the guide bars are round rods tapped into the upper cylinder flange and also serve as cover bolts The cylinder ports are formed in a separate brass casting screwed on to the cylinder, and the valve chest is secured to this in a similar manner The slide valve is driven by two links and a crosshead from levers on a rocking shaft below; this shaft is provided with a double-ended lever having a pin at each end, with which a gab rod, driven by a fixed eccentric on the crank axle, could engage ; one pin gives the forward motion and the other the backward The side rods and the valve rod have been altered at their lower ends to suit their subsequent uses.

The wheels are of the suspension type patented in 1826 by Theodore Jones. The tire is of wrought iron 3·5 in. wide, shrunk on a cast iron rim provided with bosses having conical holes for the heads of wrought iron spokes 1 in. diam. These spokes pass alternately to the one end of the recessed hub, and then to the other, and are there secured by inside nuts so that the spokes cannot be under compression. The nuts are prevented slacking back by an annular plate put over them. The wheels are 4·23 ft. diam.

Inv. 1904–16 and 1914–83. 28652; S M. 546.

36. MODEL OF THE "NOVELTY" LOCOMOTIVE (working). (Scale 1 : 8.) Made from drawings prepared in the Museum, with the assistance of information supplied by A. Braithwaite, Esq., 1905. Plate IV, No. 2.

This model represents the "Novelty" as it appeared at the Rainhill trials in 1829. The engine was carried on four equal wheels, 50 in diam, and had two vertical cylinders, 6 in. diam. by 12 in. stroke, which acted by means of bellcranks and horizontal connecting rods on a crankshaft carrying the single driving wheels The tractive factor was 8·64.

The boiler consisted of a vertical cylindrical chamber containing the firebox, and a horizontal barrel, 13 in diam by 10 ft in length, containing an internal flue or tube 31 ft. long, tapering from 4 in in diam at the firebox end to 3 in. diam at the chimney, this flue was arranged as a coil of three limbs, and through it the hot gasses passed from the top of the firebox, descending to the chimney at the other end of the barrel The ashpan was closed, and air for the fire was forced in below the grate by a blowing machine worked by one of the bellcranks; there was no blast pipe, the exhaust steam from the cylinders escaping directly into the air The coke was supplied to the grate down a central tube above the firebox, which was closed by a pair of shutters to prevent its becoming a chimney The grate was hinged and had an area of about 1·8 sq ft.; the heating surface of the firebox was about 9·5 sq ft., and that of the tube about 33 sq ft. The steam pressure was limited by a spring-loaded valve, and feed water was supplied by a force pump; the locomotive had no tender, but carried a water tank beneath the boiler, and coke in baskets on the platform.

The framing was of wood mounted on springs, the axleboxes and springs were tied together on each side by an iron bar, one end of which was connected with the frame by links The wheels were of the suspension type patented by Theodore Jones in 1826. The total weight of the engine in working order was 3·85 tons.

Inv. 1905–10 28837, 31070

37. LITHOGRAPH OF THE "NOVELTY" LOCOMOTIVE. Presented by Mrs. Goodrich, 1875.

This is a coloured lithograph from a contemporary drawing by C. B Vignoles. It shows Braithwaite and Ericsson's locomotive "Novelty," of 1829, drawing a train composed of a goods wagon, a vehicle described as a railway omnibus, and two private carriages mounted on trucks.

Inv. 1875–42.

38. MODEL OF BRANDRETH'S "CYCLOPEDE." (Scale 1 : 6.) Presented by Admiral Sir T. Brandreth, K.C.B., 1894.

This model shows the machine patented in 1829 by T. S Brandreth and entered for competition at the Rainhill trials in the same year It was a kind of horse velocipede, intended for use on railways, but as the speed attained was only six miles per hour the device was abandoned The "Cyclopede," with its horse, weighed 3 tons, so that, in proportion to the power exerted, it was very heavy, and would require much more than one horse-power to drive it at any considerable speed The machine was carried on four flanged wheels, which, by spur gearing, were driven by the endless apron or platform on which the horse walked. This apron was formed of boards 4 in by 1·5 in., each fitted with end cleats which extended half way across the adjacent boards, and so distributed the weight. The boards were secured to two endless ropes passing over return pulleys at each end; six intermediate pulleys supported the upper side of the apron, and four the lower or slack side.

The sketch shows the original arrangement of the complete machine; but in the model the apron has a slope of 1 in 13, so that the horse was compelled to walk, as the platform receded under the action of the weight of the animal. This form of horse gear is now used in some districts for driving agricultural machinery.

A photograph of a letter from Stephenson to Hackworth regarding this proposal is shown Inv. 1894-136 19259

39. LITHOGRAPH OF THE RAINHILL LOCOMOTIVES (1829). Presented by John Braithwaite, Esq., 1865.

This is a contemporary print showing the three locomotives "Rocket," "Sans Pareil," and "Novelty," which competed at the Rainhill trials in October, 1829 The conditions of the trials are also given. Inv. 1865-74

40. DRAWING OF THE THREE LOCOMOTIVE ENGINES WHICH COMPETED AT RAINHILL IN 1829. (Scale 1 : 24) Prepared in the Museum, 1892

When the Liverpool and Manchester Railway was nearing completion it became necessary for the directors to determine upon the motive power to be employed, and, having received reports from their engineers favourable to the employment of locomotives, they offered, in April, 1829, a premium of 500*l* for the engine which would best fulfil certain conditions, particulars of which are given on an adjacent lithograph

Messrs J U Rastrick, N Wood, and J Kennedy were appointed judges, and the trials were commenced on October 6th, 1829

Five engines were entered for the competition, viz —

The "Rocket," by Robert Stephenson (*see* No 24)

The "Novelty," by Messrs. J Braithwaite and J Ericsson (*see* Nos 35 and 36)

The "Sans Pareil," by Timothy Hackworth (*see* No 31)

The "Perseverance," by T Burstall

The "Cyclopede," by T S Brandreth (*see* No 38)

The trials were conducted at Rainhill near Liverpool, on a level piece of the line, 1·75 miles in length, of which 220 yards at each end were allowed for starting and stopping. The competing engines were required to make ten double trips, going over the central 1·5 miles at full speed, which was to represent a journey from Manchester to Liverpool Then a fresh supply of water and fuel could be taken up and the second ten trips performed, which represented the return journey, the average speed throughout to be not less than 10 miles an hour

The first engine to be tried, on October 8th, was the "Rocket", it weighed 4·25 tons and had a load of 12·75 tons attached to it It completed the whole of the journey at an average speed, over the central portion of the track, of 13·8 miles an hour, its maximum speed for one trip being 24 1 miles an hour

The next, on October 10th, was the "Novelty," which, on account of its elegant appearance, was the popular favourite; it weighed 3·05 tons without water tank and fuel, and its load was 7·7 tons, but, after running 3·25 miles, it was stopped by a defective feed pipe After being repaired it ran an unofficial trip at 19·4 miles an hour On October 14th it was again brought out and ran about six miles, attaining a maximum speed of 16·1 miles an hour, then some of the boiler joints gave way, and this caused its withdrawal from the competition

The "Sans Pareil" appeared before the judges on October 13th, when it was found to weigh 4·77 tons, and should therefore have been carried on six wheels It was thus rendered ineligible to compete for the prize, but was allowed to take its trial. The load attached to it was 14·32 tons, but, after running 27·5 miles at an average speed, over the central portion of the track, of 13·95 miles an hour, and a maximum speed for one trip of 17·5 miles an hour, the feed pump broke down and ended the trial

The "Perseverance," about which little is known save that it had a vertical boiler with small heating surface, was also tried, but only attained a speed of four or five miles an hour and was withdrawn, while the "Cyclopede," which was also found unsatisfactory, had a speed of six miles an hour.

The " Rocket," which was the only engine to complete the journeys and fulfil all the conditions, was therefore awarded the prize. These trials convinced the directors of the suitability of the locomotive as a means of haulage. The railway was completed and formally opened for public use on September 15th, 1830. Inv. 1892–84. 19614

STEAM LOCOMOTIVES, 1830 TO 1870.

41. DRAWING OF EARLY LOCOMOTIVES EMPLOYED ON THE LIVERPOOL AND MANCHESTER RAILWAY (1829–34). (Scale 1 . 24) Prepared from tracings and particulars presented by C. E Stretton, Esq , 1895.

In this drawing eight examples selected from the first thirty-six locomotives used on this line between 1830–34 are shown, and the leading dimensions given, together with a section of the line

The diagram shows the " Rocket " in its original state, as it was at the Rainhill competition in October, 1829 (*see* No 25)

The " Northumbrian," which was the finest engine at the opening of the line in September, 1830, very much resembled the " Rocket," as it now is, with its cylinders nearly horizontal

The " Planet " showed a great change in the arrangement of the locomotive and one that has since become almost universal, the cylinders being horizontal and placed inside and under the smokebox

The " Mercury " was a similar engine in which nearly all the other features of the present locomotive are noticeable This engine was, in December, 1833, converted into a six-wheeler, as shown in red lines

The " Samson " had four equal wheels, coupled by external rods On a cotton handkerchief printed in 1831 is represented the opposite side of this engine, showing a large hand-power feed pump, an arrangement that was for some years adopted to prevent delay should the engine-driven pump fail The above five designs were all carried out by Messrs R Stephenson & Co , by January, 1831

The " Liver," by Edward Bury (*see* No 45) was a four-wheeled passenger engine, of a type that was afterwards extensively built by him, even after nearly all railways had adopted some form of six-wheeled engine

The " Patentee," by Messrs R Stephenson & Co. in 1834, was a six-wheeled engine, with single drivers in the middle, and no flanges to them. It had a " steam " brake

The " Swiftsure," by Messrs Forrester & Co , in 1834, was an outside cylinder engine with single drivers At the time it was constructed, however, it gave considerable trouble and dissatisfaction owing to the defective balancing of the reciprocating parts and the extreme width between the cylinders

Inv 1895–53 15602

42. PHOTOGRAPHS OF THE " INVICTA " LOCOMOTIVE Presented by Sir David L. G. Salomons, Bart., 1907.

This locomotive was built in 1830 by Messrs R Stephenson & Co , for the Canterbury and Whitstable Railway After undergoing various alterations and remaining partially dismantled for many years, it was restored to the condition shown by the photographs and is now preserved at Canterbury

The engine has cylinders 10 in diam by 18 in stroke, placed in front and inclining downward to drive four coupled wheels 48 in diam , giving a tractive factor of 37 The valves are placed above the cylinders and driven by sliding loose eccentrics which are reversed by a pedal. When originally built, the boiler was similar to that of the " Rocket," there being a barrel containing 25 tubes 3 in diam and a rectangular water jacketed firebox bolted on behind (*see* No. 24). The firebox and tubes were subsequently removed, the shell lengthened, and a single flue tube fitted. The engine stands on wrought iron fish-bellied rails. Inv. 1907–27.

43. ENGRAVING OF THE "NORTHUMBRIAN" LOCOMOTIVE (1830). Received 1914.

This a contemporary engraving, by I. Shaw, showing the locomotive "Northumbrian" constructed by Messrs. Robert Stephenson & Co., in 1830, for the Liverpool and Manchester Railway. It led the procession at the opening of the railway on September 15th, 1830. The engine is notable as being the first in which the firebox was incorporated with the boiler shell.

It was a four-wheeled engine, generally similar to the "Rocket," but its outside cylinders were nearly horizontal and were 11 in. diam. by 16 in. stroke; the driving wheels were 5 ft diam so that the tractive factor was 32·3. The main frames were formed of vertical plates to which the axlebox horns were bolted The boiler barrel was 3 ft. diam. by 6·5 ft. long, and contained 132 tubes 1·625 in. diam The total heating surface was 411·75 sq ft. and the grate area was 6·11 sq ft

The rear wheels were 32 in. diam and the wheel base was 7·5 ft. The weight in working order was 7·3 tons of which 4 tons rested on the driving wheels

Inv. 1914–290. S.M. 1396.

44. LITHOGRAPH OF "WILLIAM THE FOURTH" LOCOMOTIVE (1830). Presented by R. B. Prosser, Esq., 1901.

This was one of two locomotives built in 1830 by Messrs J. Braithwaite and J. Ericsson, under a contract with the Liverpool and Manchester Railway Co They were to weigh less than 5 tons and to draw a gross load of 40 tons at a speed of 15 miles an hour on a coal consumption of 5 lb per ton per mile; they proved failures, however, owing to shortness of steam and were not accepted.

The engines were of similar construction to the "Novelty" (*see* No. 36). They had four equal wheels 56·5 in diam, and two vertical cylinders 12 in. diam. by 14 in stroke By means of bellcranks and horizontal connecting rods, motion was given to a crankshaft on which the single driving wheels were fixed The tractive factor was 35·7 The boiler was larger than that of the "Novelty" and differed from it in the manner of producing the draught, the hot gases being exhausted by a fan placed at the end of the flue tube in the vase-shaped structure shown on the top of the steam chamber The framework was carried on springs and Jones's patent suspension wheels, while fuel and water were carried on a separate tender.

Inv 1901–124.

45. DRAWING OF EARLY LOCOMOTIVES BUILT BY MESSRS. EDWARD BURY & CO., (1830–49) (Scale 1 . 24.) Prepared from tracings and particulars presented by C E Stretton, Esq, 1899.

The firm of Messrs Edward Bury & Co, of the Clarence Foundry, Liverpool, had existed for some years as a general engineering establishment, when, in 1829, they commenced the construction of their first locomotive During the following twenty years about 415 engines were constructed at the works, which were finally closed in 1850

No 1 engine on the firm's book was the "Dreadnought," completed in March, 1830 It had six coupled wheels, 48 in. diam, connected with an independent shaft upon which two outside inclined cylinders, 10 in diam by 24 in. stroke, acted, its tractive factor was therefore 50 The boiler was of the return flue type, with 200 sq. ft. of heating surface, and there was a tender at each end of the engine This locomotive was from the first unsatisfactory, and was subsequently altered to the four-wheeled type, by the removal of the central axle; but, after having been tried on several railway lines, it was dismantled within ten months of its completion

No 2 engine, the "Liverpool," constructed in 1830, embodied improvements suggested by the experience gained with No. 1 and by Mr Kennedy, who had previously been engaged at Stephenson's works It was an engine with four coupled wheels, 72 in diam, and a pair of inside cylinders 9 in diam. by 18 in. stroke The original boiler is said to have contained a number of convoluted flues, and the framing was of the bar type. There was a single four-wheeled tender, and the whole arrangement embodied the distinctive features of the afterwards well-known Bury type of light engine

No. 3 engine, the "Liver," built to the order of the Liverpool and Manchester Railway Co, was a four-wheeled passenger engine with a single pair of driving wheels, 60 in diam, driven by inside cylinders 11 in. diam. by 16 in. stroke,

so that its tractive factor was 32. Its weight in working order was 10 tons, and its heating surface 324 sq. ft.; the grate area was a little over 8 sq. ft. The engine ran 22,651 miles in the forty-three weeks that it worked in 1832, and 23,134 miles in the following year.

By the close of the year 1834 sixteen Bury locomotives had been constructed, of which nine had been sent to America; the output subsequently increased, but about 1846 the firm, which had become Messrs. Bury, Curtis & Kennedy, found that the light four-wheeled engine that they had persistently advocated was becoming unpopular, so a six-wheeled type was reluctantly introduced

No. 190, built for the London and Birmingham Railway, in 1846, had four coupled wheels, 60 in. diam., and a pair of trailing wheels 42 in. diam. The cylinders were 15 in. diam. by 20 in. stroke, and the tractive factor was 75; the heating surface was 795 sq ft.

No. 192 was also built in 1846 for the London and Birmingham Railway, and was a somewhat similar six-wheeled engine to the preceding, but had single drivers

No. 220, built in 1846 for the Bristol and Birmingham Railway, had six wheels, 60 in. diam., all coupled and driven by a pair of cylinders 16 in. diam. by 24 in. stroke, giving a tractive factor of 102 The total heating surface was 1,014 sq ft

No. 280, built in 1847, followed a design that was accepted by several railway companies. It had four coupled wheels, 60 in diam., with the firebox placed between their axles, and a pair of leading wheels 48 in diam., the cylinders were 16 in diam. by 22 in stroke, and the tractive factor was 94. The heating surface was 1,011 sq. ft.

No 301, built in 1848 for the London and North Western Railway, was a six-wheeled engine with a single pair of drivers, 78 in diam, and a pair of cylinders 16 in. diam by 22 in stroke, giving a tractive factor of 72, in this design Bury abandoned his high-domed firebox, and adopted what he termed his "low-domed" boiler.

No. 355 was the celebrated "Liverpool," built in 1848 for the London and North Western Railway, under Mr. T. R. Crampton's patent. It had eight wheels, but only a single pair of drivers, arranged behind the firebox and driven by outside cylinders The driving wheels were 96 in. diam., and the cylinders 18 in diam by 24 in stroke, giving a tractive factor of 81; the six other wheels were 48 in diam The grate area was 21·5 sq ft, and the total heating surface 2,290 sq. ft., while the total wheel base was 18·5 ft and the overall length of the engine 27 ft. The weight of the engine in working order was 35 tons, of which 12 tons were on the driving wheels, the weight of the tender was 21 tons. This engine conveyed express trains from London to Wolverton, and in one case kept time when hauling forty carriages, which was considered to exceed the combined power of three ordinary engines, when tested in 1849 with a light load, the engine attained a speed of 78 miles per hour (*see also* No 64)

No 359 was built in 1849 for the Great Northern Railway. It had four coupled wheels 69 in diam, and a pair of leading wheels 51 in diam, while the cylinders were 15 in diam by 22 in stroke, giving a tractive factor of 72

Inv. 1899-110. 25087

46. DRAWING OF THE LOCOMOTIVES EMPLOYED ON THE LEICESTER AND SWANNINGTON RAILWAY (1832-46). (Scale 1 · 24.) Prepared from tracings and particulars presented by C. E. Stretton, Esq., 1892.

The Leicester and Swannington Railway was commenced in 1830, and opened on July 17th, 1832, Robert Stephenson being the engineer The main line was 16 miles in length, but included two heavy inclines that could not be worked by locomotives The Bagworth incline, 950 yards in length, with a gradient of 1 in 29, was worked by a rope, the loaded train from the colliery at the summit pulling up the empty one; but the Swannington incline, with a gradient of 1 in 17, was worked by a stationary engine and rope. The remainder of the line had gradients of from 1 in 97 to level, and was worked by the engines illustrated. The gauge was 4 ft 8·5 in., and the rails of wrought iron of the "fish-bellied" pattern, weighing 35 lb. per yard Since 1846 this railway has formed part of the Midland system.

Particulars are given of the whole ten engines employed; the "Goliath" and "Hercules," however, are not shown in the drawings, as they were almost identical with the "Samson." The rapid increase in power and heating surface will be seen to be remarkable if the "Comet" of 1832 is compared with the

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Inv. 1914–290. S M 1396.

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Inv 1901–124

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No 1 engine on the firm's book was the "Dreadnought," completed in March, 1830 It had six coupled wheels, 48 in diam., connected with an independent shaft upon which two outside inclined cylinders, 10 in diam by 24 in. stroke, acted, its tractive factor was therefore 50 The boiler was of the return flue type, with 200 sq. ft of heating surface, and there was a tender at each end of the engine This locomotive was from the first unsatisfactory, and was subsequently altered to the four-wheeled type, by the removal of the central axle; but, after having been tried on several railway lines, it was dismantled within ten months of its completion

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Particulars are given of the whole ten engines employed; the "Goliath" and "Hercules," however, are not shown in the drawings, as they were almost identical with the "Samson." The rapid increase in power and heating surface will be seen to be remarkable if the "Comet" of 1832 is compared with the

"Atlas" of less than two years later. The "Samson" was the first engine fitted with a steam trumpet or whistle. This trumpet was the suggestion of the manager, Mr. Bagster, to George Stephenson, who had it constructed by a local instrument maker.

The "Samson" and "Goliath," owing to their increased length and short wheel base, pitched seriously. To prevent this, Stephenson fitted a pair of trailing wheels behind the firebox, as shown in red, and had the flanges removed from the middle pair of driving wheels. The success was so complete that he decided to discontinue building four-wheeled engines. The arrangement of the "Atlas" was derived from the improved "Samson" class by increasing the size of the added trailing wheels, and then coupling the three axles, but the boiler and cylinders were considerably larger, and the locomotive, which was the most powerful one of its time, weighed 17 tons. The company then purchased the "Liverpool," by Edward Bury, a four-wheeled engine weighing 10 tons; but although it worked well for many years, the succeeding engines were all heavier and closely resembled the "Atlas," although built by other makers. Further particulars of this interesting railway have been collected and published by Mr Stretton Inv 1892-189 25204.

47. DRAWING OF "PIONEER" LOCOMOTIVE. Presented by C. and C E. Stretton, Esqs., 1903

This represents an engine built by Messrs Rothwell, Hick & Rothwell, at Bolton, in 1832, for the Bangor and Piscataguis Railway, U S A

It was a four-wheeled passenger engine with inside cylinders 9 in diam by 18 in. stroke, and driving wheels 54 in diam, thus having a tractive factor of 27. The valve chests were between the cylinders and the valves driven by loose eccentrics, hand levers being added for reversing The boiler barrel was 32 in diam, and contained 47 tubes 1·75 in diam, the fire-box was of the Bury type, D-shaped with a domed top surmounted by the safety valve, the total heating surface was 182 sq ft, and the grate area 6 sq ft The leading wheels were 36 in diam and the wheel base 5 ft, the frames were of wood flitched with iron plates which also formed the axle-box guards Inv 1903-10.

48. DRAWING OF EARLY LOCOMOTIVES, BUILT AT THE VULCAN FOUNDRY (1833-53) (Scale 1 24) Prepared from particulars supplied by the Vulcan Foundry Co, 1896.

The Vulcan Foundry at Newton-le-Willows, near Warrington, was established in 1832 by Charles Tayleur, of Liverpool, and Robert Stephenson At the time Lancashire was a centre of railway enterprise, so that the new works were soon fully engaged in locomotive building as well as on general constructional iron work Their first locomotive was named "Tayleur," and the second "Stephenson", both were completed in 1833, and in 1840 the works built their 100th engine In 1847 the name of the firm was changed from Charles Tayleur & Co to the Vulcan Foundry Co

The sheet shows ten of the early locomotives constructed at these works, the examples have been so selected as to indicate the variety in the types then built

No. 4, built 1833, for the Camden and Woodbury Railroad, U S A, was a bogie engine with 9 in. by 14 in inside cylinders and single drivers 54 in. diam, with the cranked axle behind the fire-box, the tractive factor being 21

No 8, built 1834, for the Liverpool and Manchester Railway, was a four-wheeled goods engine, with 11 in by 20 in inside cylinders and wheels 60 in diam., the tractive factor being 40·3

No. 20, built 1835, for the South Carolina Railroad, U S A, was a bogie engine, with 10 in. by 16 in. outside cylinders and single drivers 54 in diam, the tractive factor being 30; the bogie wheels were of two sizes

No 25, built 1836, was No 1 engine of the London and Greenwich Railway; it was a four-wheeled locomotive, with inside cylinders 10 in by 16 in. and single drivers 60 in diam., the tractive factor being 21

No. 35, built 1836, for Mr. Hargreaves, of Bolton, was a six-wheeled engine with four coupled drivers 68 in. diam and 13 in by 18 in inside cylinders, the tractive factor being 45. It is shown on stone sleepers and a parallel rail of the period.

No. 52, built 1837, for the Great Western Railway (7 ft gauge), was a six-wheeled engine with single drivers 96 in. diam, and 14 in by 16 in inside cylinders, the tractive factor being 33.

No. 61, built 1838, was a light engine used by a contractor on the London and Birmingham line. It had 12 in. by 16 in. inside cylinders and 54 in. single drivers, the tractive factor being 43.

No. 231, built 1845, for the line between Bristol and Birmingham, was a six-wheeled engine with single drivers behind, 72 in. diam., and 15 in. by 24 in. outside cylinders, arranged between four wheels of equal size; the tractive factor was 75.

No. 316, built 1848, for the Shrewsbury and Chester Railway, was a four-wheeled inside cylinder engine with a wheel-base of 11·5 ft. The wheels, 63 in. diam., were coupled to an intermediate axle, which was driven by 16 in. by 24 in. inside cylinders, giving a tractive factor of 97·5

No. 346, built 1853, for the Shrewsbury and Hereford Railway, was a six-wheeled engine, with single drivers 66 in. diam., driven by 15 in. by 20 in inside cylinders, but with the valve chests and motions outside the frames; the tractive factor was 68

A lithograph on the wall shows the firm's practice in 1838, while on the Leicester and Swannington sheet (*see* No 46) is shown another engine by the Vulcan Co. Inv 1896–144. 17181

49. SIX SHEETS OF DIAGRAMS OF LOCOMOTIVES. (Scale 1 : 96) Presented by Theodore West, Esq, 1886.

The original diagrams of which there are lithographs, were prepared to illustrate a paper read by Mr West before the Cleveland Institution of Engineers in 1886, on the development of the locomotive in this country and America. The outlines are to scale, and the leading dimensions and particulars of the engines, are given on the sheets Inv 1886–84.

50. PHOTOGRAPH OF "HIBERNIA" LOCOMOTIVE. Received 1861

This was one of the three engines built in 1834 by Messrs Sharp, Roberts & Co, of Manchester, for the Dublin and Kingstown Railway They were of a novel type proposed by Richard Roberts, the cylinders being placed vertically over the centre line of the leading wheels and working the driving wheels by connecting rods and equal-armed bellcranks The cylinders were 11 in diam by 16 in stroke, and the driving wheels 60 in, giving a tractive factor of 45, the leading wheels were 36 in diam There were no eccentrics to actuate the valves, short arms on the bellcranks being used instead to move rocking shafts near the foot-plate. The valves were tubular without lap or lead, and the pistons were without rings, but had white metal bands exactly fitting the cylinders

The engines proved unsteady in running, so that, with the exception of the "Experiment," for the Liverpool and Manchester Railway, no others were built Inv 1861–58

51. DIAGRAM MODELS OF BALANCED LOCOMOTIVE WITH EXPANSION VALVES (working). (Scale 1·3) Contributed by R. Bodmer, Esq, 1857

These two models show the method of balancing the reciprocating parts of a locomotive patented by Mr J G Bodmer in 1834, and tried with some success in 1844–46 Each cylinder has two pistons, one with a tubular rod within which the other rod slides; the pistons, being connected with cranks set at 180 deg. with one another, continually move in opposite directions, thus almost completely balancing their inertia stresses. The cylinders have a port at each end and another at mid-length The end ports are led to one of the steam ports of an ordinary three-ported valve face, and the middle one to the other port, so that the steam is distributed by an ordinary slide valve.

The models show the application of a right and left hand screwed valve spindle, as a means of changing the point of steam cut-off by altering the amount of valve lap. Mr. J. G Bodmer in 1841 patented this arrangement as applied to a piston cut-off valve working in a separate chest at the back of the ordinary valve. Later in the same year, Mr. Horatio Allen patented, in America, the usual form with flat valves, and with the cut-off valve working upon the back of the main valve, while, in 1842, the same arrangement was patented in France by Mr. J. J. Meyer, by whose name it is generally known.

One model shows a cylinder and its gearing for an outside cylinder locomotive. The valves are of the piston form, and the cut-off valve works within the main valve and has a screwed spindle to give a variable lap; the main valve spindle is hollow and the other slides within it. The other model represents two cylinders, valves, etc., for an inside cylinder engine, the valves being of the Meyer type, and placed between the cylinders. The cut-off valve spindles are geared together and are rotated from the foot-plate The reversing gear, which was of the ordinary kind, is not shown on the models. Inv. 1857–1 and 2.

52. MODEL OF PASSENGER LOCOMOTIVE (1837) (working). (Scale 1 : 12.) Received 1896.

This model was made by Mr J. Dawson, District Superintendent at Southampton, of the London and Southampton (now the London and South Western) Railway It represents an engine of the standard passenger type of the period. It had six wheels, a single driving axle, inside cylinders and outside frames.

The cylinders were 12 in diam. by 18 in. stroke, and the driving wheels were 60 in. diam, so that the tractive factor was 43. The leading and trailing wheels were 42 in. diam, and the wheel-base was 11 ft The smoke-box completely enclosed and supported the cylinders, but the valves were placed above them and not between, as generally arranged somewhat later. The crosshead guides were of the four-bar type, and above them were arranged rocking shafts for driving the slide valves.

As this model was made before the introduction of the link motion, its valve gear is of particular interest. The valve of each cylinder was provided with two eccentrics, one for forward running and the other for backward; the ends of the eccentric rods finished in notches or gabs and were supported by links from a horizontal reversing shaft. Each pair of gabs embraced a pin connected with one of the slide valve rods By a lever on the right-hand side of the platform the reversing shaft could be turned so as to throw one set of gabs off the valve pins and the other set on, or leave them in the intermediate position when the valve rods were free for independent movement by the hand levers, which were on the left side of the platform, one lever being provided for each cylinder. This gear entailed the manipulation of three levers in reversing and gave no means of altering the cut-off, but it contained the four eccentrics of the present locomotive link motion.

The boiler had a barrel 42 in. diam and 8 ft. long, with a fire-box of circular section having a domed crown; the inner fire-box was flattened to form the tube plate. A spring-loaded safety valve was mounted on a dome over the fire-box and another on the barrel Two long-stroke feed pumps were provided, driven directly from the crossheads

The frames shown are of solid bars, but it is probable that they were intended to represent the early timber frames which were flitched with iron plates on both sides. The boiler was carried on wrought iron brackets resting on the frames. There was no shelter for the driver, the only protection on these early locomotives being a hand-rail as shown. Inv 1896–87 S M 1352

53. DRAWING OF EARLY LOCOMOTIVES OF THE GREAT WESTERN RAILWAY (1837–55) (Scale 1 : 24) Prepared chiefly from particulars and tracings furnished by C E. Stretton, Esq, 1898.

The prospectus of the Great Western Railway Co was issued in 1833, the Act authorising construction was passed in 1835, and the broad gauge of 7 ft., proposed by Brunel in 1835, was sanctioned by Parliament in 1837 The first section of the line, from Paddington to Maidenhead, a distance of 22·5 miles, was opened in 1838, and the line to Bristol in 1841; the extensions to Cornwall, South Wales and Cheshire were carried out subsequently. The rails used were of the bridge section, weighing 44 lb per yard, and were supported on longitudinal sleepers resting on short piles and tied together by transoms. The piles were soon abandoned, but the longitudinal system was retained, the extra width of the broad gauge probably rendering it more economical than the use of transverse sleepers. In 1845 the railway had 274 miles of line laid with the broad gauge exclusively; in 1854 the mixed gauge, obtained by the use of three rails, which had been introduced in 1847, was extensively adopted; but by 1867 the broad gauge track had increased to 1,456 miles. In 1869 was commenced the conversion of some of the mixed gauge track into narrow gauge, and at the same time

the manufacture of unconvertible broad gauge stock was restricted; in 1892 the broad gauge rolling stock was entirely withdrawn, and the system has since been worked exclusively on the standard gauge of 4 ft. 8·5 in. An adjacent photograph shows the last broad gauge mail train leaving Paddington station, May 20th, 1892.

The first engine of the Great Western Railway was the "North Star," built in 1837 by Messrs. R. Stephenson & Co, although not designed for this line. It remained in use till 1870, and ran more than 400,000 miles. It had a pair of inside cylinders 16 in. diam. by 18 in. stroke, and single driving wheels 7 ft. diam., giving a tractive factor of 55. The heating surface was 850 sq. ft, and the grate area 11·76 sq. ft. The link motion shown was added some years after the engine was built. This engine was the first of twelve forming the "Star" class, all built for this line by Messrs R. Stephenson & Co. in 1837–41.

"Vulcan," the second engine of the line, was built in 1837 by the Vulcan Foundry Co, being No 52 in their books. It was a six-wheeled engine with single driving wheels 96 in diam., and inside cylinders 14 in. diam. by 16 in. stroke; the tractive factor was 32·6.

"Lion," the seventh engine of the railway, was built by Messrs. Sharp, Roberts & Co in 1838. It was a six-wheeled engine with inside cylinders 14 in. diam. by 18 in stroke, and a pair of single 6 ft driving wheels. The tractive factor was 49.

"Ajax," the fifteenth engine on the line, was built in 1838 by Messrs. Mather, Dixon & Co, of Liverpool It was a six-wheeled engine with inside cylinders and outside frames and axle bearings, the cylinders were 14 in diam. by 18 in. stroke, and drove a single pair of driving wheels 8 ft in diameter, giving a tractive factor of 36·7 These wheels were without spokes, two discs of boiler plate held together by screwed stays being substituted in each, the discs, which were 0·56 in thick, were 7 in apart at the boss and 3·5 in at the rim

"Fire-fly" was built in 1840 by Messrs Jones, Turner, and Evans, to designs by Sir D Gooch It had a pair of inside cylinders 15 in diam by 18 in stroke and single drivers 7 ft diameter, the tractive factor was 48, and the engine in working order weighed 24·2 tons. Altogether sixty engines to this design were constructed by various makers

"Iron Duke" was built at the Swindon Works in 1847 to designs by Sir D Gooch, the cylinders, 18 in diam by 24 in stroke, worked single drivers 96 in diam, thus giving a tractive factor of 81 The grate surface was 21 sq ft, and the total heating surface 1,952 sq ft The "Iron Duke" is shown with its tender, as both remained for many years the standards for the Great Western line, until the abolition of the 7 ft. gauge was definitely decided upon. The engine had four small wheels in front, with the axle-boxes on each side connected by a single plate spring, which acted also as an equalising lever, an arrangement that was extensively adopted for many years, but was ultimately replaced by the bogie

"Lalla Rookh" was built in 1855 by Messrs R Stephenson & Co, to designs by Sir D Gooch, it had 17 in cylinders by 24 in stroke, and coupled drivers 7 ft in diameter, giving a tractive factor of 82·5. This adaptation of the "Iron Duke" design to an engine with coupled drivers was followed in ten engines, but was not afterwards repeated Inv. 1898–79 19150.

54. DIAGRAM OF BROAD GAUGE LOCOMOTIVES, GREAT WESTERN RAILWAY (1837–92). (Scale 1 : 96.) Presented by the Locomotive Publishing Co., 1906.

This diagram, from drawings by Mr G. F Bird, shows fifty-three types of engine used on the Great Western Railway from its commencement until the abolition of the broad gauge. Dates and names are given Inv 1906–16.

55. PHOTOGRAPHS OF EARLY AMERICAN LOCOMOTIVES. Presented by C. E. and C. Stretton, Esqs., 1900.

These were taken from the relics and models of America's first locomotives, dating between 1831 and 1844, as exhibited at Chicago in 1893. Each has a short description beneath it. Inv. 1900–9.

56. MODEL OF EARLY AUSTRIAN LOCOMOTIVE (working). (Scale 1 : 6.) Made by Philipp Wolf. Received 1902.

This model, which was made in 1843, represents a type of locomotive, introduced in 1837 by William Norris, of Philadelphia, for working on lines having steep inclines and sharp curves, such engines were largely used on the Austrian railways at their commencement in 1838, and many of the class were subsequently built at Vienna. Similar locomotives were sent by Norris to England in 1840, and some of them were used for working the Lickey incline on the Birmingham and Gloucester Railway.

The engine represented had inclined outside cylinders, and a single driving axle in front of the fire-box, while the forward end of the engine was carried by a four-wheeled swivelling bogie, so that great flexibility was secured. The cylinders were 10·5 in diam by 21 in stroke and the driving wheels 46·5 in diam., so that the tractive factor was 50; the bogie wheels were 30 in diam, with their centres 2,875 ft apart, while the total wheel-base of the engine was 9·875 ft on a gauge of 5 ft. Each cylinder was provided with two square guide-bars, and the crossheads working on them had adjustable slide blocks

The valve chests were arranged above the cylinders, and the valve rods were driven, through a rocking shaft, by four eccentrics on the driving axle There was a forward and a backward eccentric to each cylinder, and each eccentric rod ended in a notch or gab provided with a spreading jaw or fork, the gab ends of each pair of rods faced each other and were suspended by links from a reversing shaft actuated by a lever on the foot-plate, so that either the forward or the backward eccentrics could be used for actuating the valves As there was no intermediate position, this valve gear did not permit of the grade of expansion being altered, so that the speed was regulated entirely by throttling

The boiler was tubulous, with a barrel 8·25 ft long by 38 in. diam. and it had a dome fire-box of the Bury type, while the grate was D-shaped in plan, the heating surface was probably 400 sq ft and the grate area 6 sq ft The dome was surmounted by a spring-loaded lever safety valve, while over the middle of the boiler barrel was a locked-up safety valve directly loaded by plate springs The regulating valve was of the sliding type, manipulated by a vertical lever above the fire-door, the model shows also a glass water-gauge and a steam whistle The feed water was introduced by two long-stroke feed pumps, directly driven from the crossheads, and special arrangements were made to render the pump and check valves readily accessible, the suction pipe of each pump was fitted with a cock controlled from the foot-plate

The frame was of the bar construction, and the boiler was supported from it by brackets; the framing rested on the bogie carriage at each side, while a central swivel pin connected it with the bogie The horns were forged with the framing, which was strengthened by inclined struts passing under the horns and riveted to the framing at each end, the driving axle and those of the bogie were provided with separately adjustable plate springs The foot-plate was carried by an extension of the framing and was fitted with a hand-rail, but no protection against the weather was provided, the length of the engine was 20 ft, and its weight in working condition about 10 tons

The tender was built on double frames with the springs and axle-boxes between them, the water tank was of a horse-shoe shape, and the central space was the fuel receptacle The tender was carried on four wheels, 30 in diam and had a wheel base of 4·875 ft.; it was fitted with brake blocks between one pair of wheels and the brakes were applied by a screw actuating a vertical wedge The engine and tender were closely connected by a pin coupling, and were provided with two padded buffers at the ends, the overall length of engine and tender was 32 ft. and the total weight about 14 tons

Inv 1902-1 25230

57. DRAWINGS OF EXPERIMENTAL LOCOMOTIVES ON THE GREAT WESTERN RAILWAY. (Scale 1 · 24.) Presented by C. E. Stretton, Esq., 1891

These blue prints represent the engines "Hurricane" and "Thunderer," designed by Mr T E. Harrison, and constructed by Messrs. R and W. Hawthorn, of Newcastle, in 1838 In both engines the plan, patented by Mr. Harrison in 1836, of separating the boiler from the engines was followed The object of the arrangement was to enable a fresh boiler carriage to be attached to the engine carriage, while the former was under repair. Such an arrangement was suggested by Matthew Murray in 1826.

The "Hurricane" had two cylinders 16 in. diam., by 20 in. stroke, working direct on to single driving wheels 10 ft. diam. The "Thunderer" had two cylinders 16 in diam., by 20 in. stroke, working on to a crankshaft which, by spur gearing in the ratio 3 : 1, was connected with four coupled driving wheels 6 ft. diam.; the gearing made the equivalent diameter 18 ft. Both engines were failures, probably largely owing to the weight on the driving wheels being so small. Inv. 1891–101.

58. PHOTOGRAPHS OF LONDON AND NORTH WESTERN LOCOMOTIVES. Presented by A. M. H. Solomon, Esq., 1922.

These show typical engines used on this line between 1839–99 Each photograph has a short description beneath it. Inv. 1899–78 to 97.

59. DRAWING OF EARLY LOCOMOTIVES BUILT BY MESSRS KITSON & CO (1840–67) (Scale 1 24.) Prepared from particulars supplied by Messrs. Kitson & Co, Ltd., 1922

The Airedale Foundry at Hunslet Road, Leeds, was established in 1839 by James Kitson and Mr Laird In 1842 Mr Kitson was joined by I Thompson and William Hewitson and the firm became Messrs Kitson, Thompson & Hewitson Thompson retired in 1858, Hewitson died in 1863, and the name was changed to Kitson & Co, in 1865

No 7 was built in 1840 for the York and North Midland Railway It was a six-wheeled engine with inside cylinders 13 in diam by 18 in stroke and single driving wheels 5 ft diam, the total heating surface was 486 sq ft and the grate area 8·7 sq ft It had outside frames and a haystack fire-box and closely resembled the standard Stephenson engines of the time

No 50 was built in 1845 for the York and North Midland Railway It was a six-coupled goods engine with inside cylinders 15 in diam by 24 in stroke, and driving wheels 57 in diam, the total heating surface was 874 sq. ft, and the grate area 10 sq ft It was of the long-boiler type with inside frames and a haystack fire-box

No 60 was built in 1846 for the Orleans and Bordeaux Railway to the designs of Mr W B Buddicom It was a six-wheeled engine with inclined outside cylinders 14 in diam by 22 in stroke, and single driving wheels 66 in diam, the heating surface was 677 sq ft and the grate area 11 66 sq ft. The leading and trailing wheels had outside bearings

No 130 was one of two engines of the Crampton type built for the Midland Railway in 1848 It had outside cylinders 16 in diam by 22 in stroke and single rear driving wheels 7 ft diam. Its boiler had a heating surface of 1,062 sq ft and a grate area of 13 9 sq ft. Instead of Crampton's usual outside valve gear, this engine was fitted with Dodd's wedge-eccentric expansion and reversing gear The outside framing was very massive and bearings were provided in them for the leading and driving wheels, the latter involving return cranks, on the driving axle

No. 211 was a six-wheeled four-coupled engine built for the Leeds and Thirsk Railway in 1849 It had inside cylinders 16 in diam by 22 in. stroke and driving wheels 6 ft diam with inside bearings The total heating surface was 873 sq ft and the grate area 15·5 sq ft The leading wheels were 4·5 ft diam and had outside bearings

No 281, "Aerolite," was a small tank engine built in 1851 for the Leeds Northern Railway It was a six-wheeled engine with outside cylinders 11 in. diam. by 22 in stroke and single driving wheels 6 ft diam The boiler had a heating surface of 587 sq ft and a grate area of 9·8 sq ft The leading and trailing wheels were 3·5 ft. diam and they had outside bearings This engine was exhibited at the Great Exhibition of 1851.

No 372 was a six-coupled goods engine built for the London and North Western Railway in 1854. It had inside cylinders 16 in diam by 24 in. stroke and driving wheels 5·5 ft diam ; the heating surface was 1,309 sq. ft. and the grate area 16·3 sq. ft. Inside frames were used.

No. 635 was a four-coupled bogie engine built for the Copiapo and Caldera Railway, Chili, in 1858 It had inclined outside cylinders 16·5 in. diam. by 24 in. stroke and driving wheels 62 in. diam The boiler had a heating surface of 1,068 sq. ft and a grate area of 13·75 sq. ft. A very complete cab was provided.

No. 1,423 was a six-wheeled four-coupled engine, built in 1866, shown at the Paris Exhibition of 1867, and then sold to the London Brighton and South Coast Railway. It had inside cylinders 16 in. diam. by 22 in. stroke and driving wheels 66 in. diam. The leading wheels were 4 ft. diam. and had outside bearings. The boiler had a heating surface of 870 sq. ft. and a grate area of 14·2 sq. ft.
Inv. 1922–657. S.M. 1647

60. MODEL OF "BURY" PASSENGER LOCOMOTIVE (working). (Scale 1 : 12.) Received 1905. Plate V, No. 1.

This model, which was made in 1846, represents a type of locomotive introduced by Edward Bury & Co. in 1832 (*see* No. 45), but the engine shown was built about 1840, probably for the Midland Counties Railway. The engines of Bury's design were of very simple form, having only four wheels and inside cylinders directly attached to inside bar framing, so that no driving stresses were imposed on the boiler. The crankshaft had two bearings only instead of the five or six usual at the period. The feature of the boiler was the D-shaped fire-box with its high domed crown These four-wheeled engines were found to oscillate considerably at high speeds, but this defect was remedied by introducing a pair of trailing wheels as shown in the model Locomotives of this type were employed on many lines and exclusively used on the London and Birmingham Railway from 1837 to 1846.

The engine represented had horizontal cylinders 12 in. diam. by 18 in stroke and single driving wheels 66 in diam. placed in front of the fire-box, the tractive factor was 39·3 The leading wheels were 48 in. diam and the trailing wheels 36 in diam The cylinders were bolted to a pair of crossbars secured to the frames at their ends, and were each provided with four guide bars The valve chests were placed above the cylinders, in the smoke-box, and the valve rods were driven through rocking shafts by four fixed eccentrics on the driving axle There was a forward and backward eccentric to each cylinder and the eccentric rods had notches or gabs at their ends, provided with long spreading jaws opening downward, which engaged with pins on the valve levers One rod of each pair was suspended from a lever on a reversing shaft which was cranked backward in the middle, while the other two were hung from a lever pivoted at one end and having a slot engaging with the crank. The reversing shaft was actuated by a lever on the foot-plate, so that one pair of forks was lowered into gear while the other pair was lifted out, this reversing gear did not permit of variable expansion The addition of forks to the gabs enabled the eccentric rods to be put in gear at any position of the valves, and thus dispensed with the levers necessary in the earlier gears for working the valves by hand

The boiler barrel was 37·5 in diam inside and 8·21 ft long, the D-shaped fire-box being 47·5 in wide and 39·5 in. long; the internal fire-box was of iron There were eighty-six tubes, 1·875 in external diam., having a heating surface of 362 sq. ft.; the fire-box heating surface was 38 sq ft, and the grate area 7·6 sq. ft A small dome on the top of the fire-box accommodated the steam pipe and was surmounted by a spring-loaded lever safety valve, while on the barrel was a lock-up safety valve directly loaded by a helical spring The regulator was of the rotary type manipulated by a lever over the fire-door, a fitting was attached on one side of the fire-box carrying a water-gauge, cocks, and a whistle. The feed water was introduced by two long-stroke feed pumps driven directly from the crossheads

The frame was formed of single flat bars having the axle guides forged or bolted on, and was trussed with round bars, the boiler was supported from it by brackets The draw-bar was attached to a stirrup secured to the frames and embracing the fire-box; the axles were provided with separate plate springs placed above them. The wheels were built up with cast iron naves and wrought iron spokes, rims, and tires The spokes had T-heads riveted to the rims, while their inner ends were coned and cottered into sockets in the naves. The foot-plate was carried on the rear end of the frame and was fitted with a hand-rail The length of the engine was 17·75 ft and its total wheel-base 10·42 ft., but only 5·5 ft without the trailing axle; its weight in working order was about 11 tons, of which 6 tons were carried by the driving wheels.

A tender was made from drawings prepared in the Museum, and was added to the model in 1906 to complete the exhibit; it represents the form in general use from about 1833–40. This tender, which was carried on four wheels 36 in. diam., had a wheel-base of 4·58 ft. The framework was built up of wooden beams, the side frames being double with the wheels between them and covered on the outside with ornamental iron plates. The water tank was of horse-shoe

shape and rested on the top of the frames, being held by large angle irons at the corners; the coal space between the frames was lined with sheet iron. The bearings were outside the wheels with the plate springs above them. Wooden brake blocks were fitted between the wheels on one side, and these were applied by a screw actuating a vertical wedge. The buffers were padded and mounted on sliding stems which engaged with the ends of a transverse spring. The engine and tender were closely connected by a link and pin coupling having swivel joints. The tank held 640 gal. of water and about 10 cwt. of coal were carried. The weight of the engine and tender in working order was about 17·5 tons and the overall length 30·1 ft. Inv 1905–8. 29810.

61. MODEL OF PASSENGER LOCOMOTIVE (1845). (Scale 1 : 5.) Received 1908.

This sectional model represents the type of locomotive that was in general use about 1840–45 It had six wheels, a single driving axle, inside cylinders and outside frames.

The cylinders were 12·5 in diam. by 21 in stroke, and the driving wheels were 62·5 in diam, so that the tractive factor was 52·5. The leading wheels were 36·5 in diam, and the trailing wheels 33 in diam; the wheel base was 11·8 ft The smoke-box completely enclosed and supported the cylinders, the valve chests were above the cylinders, and the valves were driven through a rocking shaft by four eccentrics and the ordinary link motion, but it is probable that the engine represented was originally fitted with a gab gear The crossheads were guided by four bar. whose outer ends were supported on a transverse plate frame.

The boiler barrel was 37·75 in. diam and 8·33 ft long The fire-box was 44·5 in long and 47·5 in wide, and was fitted with a transverse water pocket in the lower part, a common feature at that period There were 98 tubes, of 2 in external diam, having a heating surface of 450 sq ft, the fire-box heating surface was 80 sq. ft, and the grate area 7 sq ft. A dome over the fire-box carried a spring-loaded lever safety valve, while another dome on the barrel accommodated the regulator valve which was of the rotary butterfly type. The feed water was introduced by a short-stroke feed pump fixed to the back of the smoke-box, below the barrel, and driven by an eccentric on the crankshaft

The frames were formed of wooden beams, flitched on both sides with iron plates, which also formed the axle-box guides, they were trussed with round iron rods and tied together by the buffer beams and the central transverse plate The plate springs for the driving axle were placed above the frames, and those for the other axles between the horn plates below them Two inside iron frames, having additional bearings for the crankshaft, extended between the smoke-box and the fire-box, to which they were secured The boiler was supported by four brackets bolted to the outside frames, and the barrel also rested upon the transverse plate The rear draw-bar and the two side buffers were connected by a horizontal plate spring, and the foot-plate was provided with hand-rails only The overall length of the engine was 19 ft. Inv 1908–10 S.M 1353.

62. MODEL OF LONG BOILER LOCOMOTIVE. (Scale 1 . 8) Lent by G. Stephenson, Esq., 1914. Plate V, No. 2.

This model, probably made about 1845, represents the type of locomotive patented by Robert Stephenson in 1841. It was known as the "long-boiler" engine, and many of this pattern were built subsequently by Messrs R Stephenson & Co The chief features of the design were the placing of the three axles under the boiler barrel, an arrangement which allowed the use of a larger boiler on an engine having a normal wheel-base, while the slide valves were placed vertically beside the cylinders The driving wheels were without flanges, to obviate lateral stresses on the crank axle; this feature had been patented by Robert Stephenson in 1833

The engine represented had outside horizontal cylinders 14 in. diam., by 22 in stroke, and driving wheels 66 in. diam, so that the tractive factor was 65·3. The leading and trailing wheels were 42 in. diam, and the wheel-base was 10·5 ft. The cylinders were bolted to the frames and were stayed together below. The valves were directly driven by Howe link motion, the links being of box form. The crossheads were guided by two bars, and the connecting rods were forked.

The boiler barrel was 38 in. diam., and 12·33 ft. long, it contained about 130 tubes, 1·75 in diam., having a heating surface of 700 sq. ft. The fire-box

was of the haystack form, 44 in. wide and 46 in. long, its grate area being 9 sq. ft. and the heating surface 51 sq. ft.; the regulator was placed in the upper part which was surmounted by a pair of spring-loaded lever safety valves. A water-gauge, cocks, and whistle were fitted, as well as a steam blower and cylinder cocks. The feed water was introduced by two short-stroke feed pumps driven by the backward motion eccentrics.

The main frames were single vertical plates placed inside the wheels, while the horns were formed by double plates riveted to them; the boiler was bolted to them at the ends and also to brackets at the middle. The drawbar was attached to crossplates fixed to extensions of the fire-box side plates which were made very thick. The axles had separate plate springs placed above the frames The engine weighed about 21 tons, of which 10 tons rested on the driving wheels; the overall length was 23·8 ft

Inv 1914-869. S.M. 1335

63. DRAWING OF 'PYRACMON" LOCOMOTIVE (Scale 1 : 10·8) Presented by A. M. H Solomon, Esq., 1922.

This represents a six coupled engine built by the Great Western Railway Co., at Swindon, in November, 1847, to the designs of Sir Daniel Gooch

The inside cylinders were 16 in diam by 24 in stroke, and the wheels were 60 in diam so that the tractive factor was 102·4 The valves were driven by Gooch's link motion, the wheel-base was 15·25 ft, and the total weight was 27 5 tons The engine worked until 1872 when it was broken up Its total mileage was 385,000.

Inv. 1899-77

64. MODEL OF CRAMPTON'S LOCOMOTIVE (working) (Scale 3 · 20) Lent by T R Crampton, Esq, 1876

This represents an express passenger engine of the type designed and patented by Mr Crampton in 1842-47, and built by MM Derosne et Cail, Paris, for the Northern Railway of France, in 1849 The general arrangement shown was adopted in order to keep the centre of gravity low, and at the same time to use large single driving wheels which were carried on an axle behind the fire-box. Locomotives of this design worked the French express services from 1849 until about 1876, and Crampton engines of the Folkestone class (*see* No 18) ran for a time on the South Eastern and the Great Northern Railways Four-coupled engines with the same arrangement of mechanism were also employed on the London, Chatham, and Dover line

The engine was carried on six wheels and had outside cylinders 15·75 in diam by 22 in stroke, the driving wheels were 82 6 in diam, and the tractive factor 66 The piston rods were extended through the front cylinder covers and formed plungers for long-stroke feed pumps The valve chests were on the tops of the cylinders, inclined outward, and the valves were driven by eccentrics, mounted on a return crank, through the usual shifting link motion, so that the whole of the mechanism was exposed to view and easily accessible. The frames were double and tied together by transverse stays, and the cylinders were bolted between the plates of each frame The two leading axles had outside bearings and the driving axle inside bearings only, the load being suspended by laminated springs placed above them.

The boiler barrel was 4 ft diam, and 11·92 ft long between the tube plates, its centre being only 4·72 ft above the rails It contained 173 tubes of 2 in external diam and four tubes of 1·75 in diam, these having a heating surface of 1,070 sq ft, the fire-box had a heating surface of 79 sq. ft. and a grate area of 15·4 sq. ft. The regulator was placed in a chamber on the barrel and external steam pipes led to the cylinders Two spring-balance safety valves were provided The smoke-box was formed as an extension of the boiler barrel, and the two exhaust pipes were led to a blast nozzle having an orifice whose area was adjustable by means of two hinged flaps.

The rigid wheel-base of the engine was 15·94 ft; the front wheels were 51 in. diam and the middle wheels 48 in diam. The weight of the engine in working order was 27 tons, the leading and driving wheels carrying 11·5 tons each and the middle wheels only 4 tons, this distribution being adopted to ensure steady running The tender was carried on four wheels 42·2 in. diam with a wheel-base of 8·2 ft., it had hand brakes on the wheels and a horse-shoe shaped water tank. The overall length of engine and tender was 45 ft.

Inv. 1876-1237 19262

65. MODEL OF PASSENGER LOCOMOTIVE AND TENDER (working). (Scale 1 : 9.) Received 1906.

This represents the type of inside cylinder passenger engine which was in general use for many years subsequent to its introduction by Mr John Gray in 1846; its extensive use was, however, largely due to the success of the engine "Jenny Lind," built by Messrs E B Wilson & Co, of Leeds, in 1847. These engines had six wheels, double frames, and a single driving axle having inside bearings only, while the leading and trailing axles had outside bearings

The model shows an engine of this type built about 1860 It had double slab frames running from end to end and braced by the cylinders and transverse frames. The cylinders were placed horizontally under the smoke-box with the valve chests between them. The valves were driven by Howe's link motion The intermediate valve rod was suspended by a link, and reversing was effected by a lever and quadrant, through a weighted countershaft below. Each cross-head had four guide-bars whose rear ends were supported by a transverse plate which also supported the boiler barrel and the reversing shaft The boiler was provided with a steam dome on the barrel surmounted by a spring-balance safety valve, and the usual fittings on the back plate of the fire-box. The feed water was supplied by two long-stroke feed pumps bolted to the frames and driven directly by the crossheads A simple weather plate was provided for the protection of the driver and fireman

The tender was carried on six wheels and was fitted with brakes which were applied by a hand wheel and screw Inv 1906–12.

66. PHOTOGRAPHS OF TREDEGAR LOCOMOTIVE. Prepared in the Museum, 1898.

These show the locomotive "Bedwellty," built by Mr Thos Ellis in 1853 for the Tredegar Iron Co, and used in hauling coal, etc, on the Sirhowy tramway between Tredegar and Newport

This engine, and eight others built at Tredegar between 1832 and 1848, were six-coupled engines with inclined cylinders at the rear end driving on to the front axle They were similar in general design to the first engine made for the company, by Messrs R Stephenson & Co, in 1829, of which the original drawing is shown in No 21 In 1882 it was discarded, and some time later the upper photograph was taken, the lower two photographs are much more recent and show the engine dismantled After 1860 the tramway was converted into a railway Inv 1898–40

67. MODEL OF INDIAN LOCOMOTIVE AND TENDER (Scale 1 4) Contributed by Lieut-Col. J P Kennedy, 1863

This represents an engine, built in 1856 by Messrs E B Wilson & Co, at the Railway Foundry, Leeds, for the Bombay, Baroda, and Central India Railway, then in process of construction The design is almost identical with Mr Alexander Allan's "Crewe" class of goods engines, built at the Crewe Works between 1843 and 1857

It had outside inclined cylinders 14 in diam by 24 in stroke, and four coupled driving wheels 60 in diam, giving a tractive factor of 78 4 The framing was double, the inside frames carrying the cylinders and the axle-boxes for the coupled wheels, while the outer frames carried the axle-boxes for the leading wheels, which were 40 in. diam The engine was fitted with Howe's link motion with suspended valve rods, and two feed pumps were driven from the two inner eccentrics Two spring-balance lever safety valves were fitted to the boiler, one on a dome over the fire-box, and the other on the barrel The engine weighed about 22·4 tons, the gauge was 5·5 ft

The tender ran on six wheels, brake-blocks, applied by a screw and hand wheel, being fitted to the three wheels along one side only Inv 1863–12 20696.

68. DRAWING OF STEAM CARRIAGE. (Scale 1 : 8.) Presented by G. Stephenson, Esq., 1914.

This drawing shows a combined locomotive and carriage built by Messrs R Stephenson & Co, in 1859 for Said Pasha, Viceroy of Egypt The locomotive was an inside cylinder, four-wheeled, single driving engine with the framing extended rearward and carried on a four-wheeled bogie The cylinders were 8 in. diam. by 14 in stroke and the driving wheels 60 in diam The leading and bogie

wheels were 42 in. diam., the fixed wheel-base was 8.58 ft., and the total wheel-base 22.25 ft. The boiler had a total heating surface of 409 sq. ft., and a grate area of 6.7 sq. ft. A water tank holding 400 gal. was fitted below the boiler, and the fuel capacity was 4 5 cwt. The carriage had a coach-shaped body and was mounted on the frame extension; its roof was carried forward to cover the foot-plate and fire-box. The vehicle was lavishly decorated as were some other engines on the Cairo and Alexandria Railway at this time. The rails were laid on cast iron pot sleepers Inv. 1914–868.

69. MODEL OF A TANK LOCOMOTIVE (working). (Scale 1 : 10.) Received 1919.

This represents an eight-wheeled four-coupled inside cylinder engine probably dating from about 1860.

The cylinders were 13 in diam by 20 in stroke, and the driving wheels were 60 in diam, so that the tractive factor was 56 The engine had outside frames and each end was carried on a Bissell truck with wheels 37 5 in diam Water was carried in a rear tank and in two side tanks

The model is fitted with a smoke-box superheater and an exhaust steam feed water heater Inv 1919-498

70. MODEL OF NORTH EASTERN RAILWAY PASSENGER LOCOMOTIVE. (Scale about 1 16) Lent by Lieut.-Col J D K Restler

This model, which is one of a collection formed by the late Sir James Wm Restler, K B E, M Inst C E, is believed to represent a six-wheeled North Eastern locomotive of the 450 class, built in 1801 It is not, however, strictly to scale and differs in some respects from the original engine

The cylinders were 16 in diam by 22 in. stroke, and the single driving wheels were 78 5 in diam so that the tractive factor was 71 8 The steam chest was placed between the cylinders, and the valves were driven by Howe's link motion controlled from the footplate by a lever and quadrant, while a screw was also provided, the nut on which was connected with the reversing lever by a short link The crossheads were guided by four bars, the outer ends of which were supported on a transverse plate frame The leading wheels were 54 in diam the trailing wheels were 48 in diam and the wheel-base was 16 ft

The boiler barrel was 4 ft diam and 10 33 ft long, the fire-box was 71 in long and 52 in wide outside and was provided with a longitudinal mid-feather A dome on the barrel contained the regulator and was surmounted by a pair of spring-loaded lever safety valves The steam pressure was 130 lb per sq in The feed water was introduced by a pair of long-stroke pumps driven directly from the engine crossheads

The outer frames were of wood, flitched on both sides with iron plates, the hornplates for the bearings of all three axles being bolted on Two inner plate frames extended from the front buffer beam to the fire-box and these carried inside bearings for the driving axle The springs for the outer bearings were all above the frames, while those for the inner driving axle bearing were suspended below it, all the springs had screw adjustment The overall length of the engine was 25 33 ft, and its weight in working order was about 28 tons

The tender ran on six wheels 4 ft diam with a wheel-base of 12 ft, it was fitted with brakes applied by a hand wheel and screw The water tank had a capacity of 2,000 gal, and the coal space held 3 tons Inv 1918–196.

71. MODEL OF AN EGYPTIAN LOCOMOTIVE (working). (Scale 1 : 8.) Lent by T. Jeffrey, Esq., 1870

This represents a tank engine built in 1862 at Alexandria by Jeffrey Bey, for working the train service between Alexandria and Suez

It is a four-wheeled engine with a single pair of drivers 5 ft diam.; the cylinders are of the outside type, 13 in diam. and 20 in stroke, giving a tractive factor of 56 The valve gear is of the usual shifting link form; the valve chests are inside, and two long-stroke feed pumps are arranged beneath the cylinders, the plungers being directly connected with the crossheads. The tank is arranged beneath the boiler, and the weigh shaft for the link motion is carried through a horizontal tube in the tank. The smoke-box is produced downward and formed into a second tank, which is an extension of the main one. Two coal bunkers are

arranged, one on each side of the fire-box, whereby the overall length of the locomotive is reduced. The blast pipe terminates in a series of nozzles superposed. The gauge fittings are all fixed to a water column attached to the boiler The various accessories carried by a locomotive are also shown, including a traversing screw jack, the stoking and firing irons, fire-bars, lanterns, etc. The engine is provided with a hand-brake, which acts on the driving wheels, and a light cab is fitted over the foot-plate to afford shelter from the intense heat of the sun.

Inv. 1870–76 19281.

72. MODEL OF EXPRESS PASSENGER LOCOMOTIVE, LONDON AND NORTH WESTERN RAILWAY (1862). (Scale 1 : 8.) Lent by Sir George W. Rhodes, Bart., 1922.

This six-wheeled locomotive "Lady-of-the-Lake," one of 60 engines of John Ramsbottom's "Problem" Class (1859–65), was built at Crewe works and, when new, was shown at the 1862 Exhibition

The outside cylinders were 16 in diam, by 24 in stroke with single driving wheels 91 5 in diam giving a tractive factor of 67 1 The steam chests passed through the frames and the valves were driven by Howe's link motion controlled from the foot-plate by a hand-wheel and screw The engine had inside frames only, the leading and trailing wheels were 43 5 in diam , and the total wheel-base was 15 42 ft The leading and driving axles had plate springs while the trailing axle had six volute springs above it Sand-boxes were fitted in front of the driving wheels.

The boiler barrel was 47 in diam by 10 5 ft long and contained 192 tubes 1.87 in. external diam having a heating surface of 1,013 sq ft. The fire-box had a heating surface of 85 sq ft and a grate area of 14 9 sq ft The steam pressure was limited to 120 lb per sq in by a Ramsbottom duplex safety valve, in which a pair of valves were pressed down by a crossbar and a central helical spring The regulator was of the double-beat balanced type The smoke-box was provided with a hopper below to discharge the ashes Feed water was supplied by a Giffard injector on one side and a pump on the other The weight of the engine in working order was 27 tons of which 11 5 tons rested on the driving wheels.

The tender was carried on six wheels 42 in diam with a wheel-base of 11 ft. Wooden brake-blocks were applied to the wheels by a screw, while the water tank was fitted with Ramsbottom's scoop for picking up water while running Its weight in working order was 17 5 tons

The weight of engine and tender in working order was 44 5 tons and the overall length was 42 8 ft

Inv 1922–689

73. MODEL OF FAIRLIE LOCOMOTIVE (working). (Scale 1 · 12.) Received 1892

This embodies the leading features of Mr R F Fairlie's arrangement patented in 1864, by which a large amount of tractive power is obtainable from a locomotive that could work on a light rail and pass round sharp curves

The boiler is mounted on the centre of two frames, each forming a distinct engine complete in itself, but both receiving steam from the common boiler which is of considerable length, and has two fire-boxes near the middle with a chimney and smoke-box at each end The engine driver stands at one side of the fire-box and the fireman at the other, protection being afforded by a central cab The frames or bogie trucks have each two cylinders and six coupled wheels, each bogie carrying one half of the weight of the boiler by a central pivot The steam is conducted from the boiler to the cylinders by two telescopic swivel pipes and a similar arrangement conveys the exhaust to the chimneys The valve gear is of the Walschaerts type. The gears of the two engines are coupled up, so that they are simultaneously controlled by a single reversing lever

There are two coal bunkers and two water tanks on the side of the boiler and two additional water tanks beneath the platform The feed is given by a direct-acting steam pump above the boiler, and two large sand-boxes are carried behind the chimneys, the engine being fitted for running in either direction, so avoiding the use of turn-tables

An engine of this type built by Messrs Neilson & Co for service in Mexico closely resembles this ; the cylinders were 16 in. diam by 22 in. stroke, with driving wheels 45 in. diam , giving a total tractive factor of 250 The heating surface was 166 plus 1,647 sq. ft., the total wheel-base 30·25 ft., and the rigid base in each engine only 8·25 ft The total weight in working order was 92·2 tons.

The peculiar bridge on which the model is shown was made to demonstrate the flexibility of the wheel-base and also to facilitate inspection of the model.

Inv. 1892–77. 19266.

74. MODEL OF PASSENGER LOCOMOTIVE, TAFF VALE RAILWAY. (Scale 1 : 8.) Received 1920.

This represents a six-wheeled four-coupled passenger engine, designed by Mr. J. Tomlinson and constructed at the Cardiff works in 1864. The model was made by Mr Thomas Hopkins, then a fitter in the works, between 1864 and 1870. Inv. 1920-637.

STEAM LOCOMOTIVES, 1870 TO 1920.

75. MODEL OF EXPRESS PASSENGER LOCOMOTIVE, GREAT NORTHERN RAILWAY (working). (Scale 1 : 8.) Made by Messrs. Baines Bros Received 1905 Plate VI, No. 1.

This represents the celebrated class of locomotives, with single driving wheels 8 ft. diam, designed and introduced by Mr Patrick Stirling in 1870 These engines successfully worked the express traffic for about 30 years, but they have now been superseded by more powerful coupled engines

The engine represented, which differs but slightly from the earlier examples, was built at the Doncaster Works in 1887 It has a pair of horizontal outside cylinders, 18 in diam by 28 in stroke, with driving wheels 97·5 in diam, giving a tractive factor of 93 The steam chests pass through the frames and the valves are driven by the usual shifting link motion, controlled from the foot-plate by a lever and quadrant

The boiler barrel is 48 in mean internal diam by 11·42 ft long and contains 174 copper tubes of 1·75 in diam, having a heating surface of 936 sq ft The fire-box has a heating surface of 109 sq ft and a grate area of 17·75 sq ft. The steam pressure is limited to 170 lb per sq in by Ramsbottom safety valves, and the steam is collected by a perforated pipe running along the upper part of the barrel, the regulator being placed in the smoke-box The fire-box crown is tied to the outer shell by screwed stays and the end plates to the barrel by diagonal stays The feed water is supplied from the tender by two injectors and enters the back plate, being led to the centre of the barrel by an internal pipe

The front end of the engine is carried on a bogie, whose pivot is placed behind the centre, there being no transverse motion, its wheels are 47·5 in diam and its wheel-base 6·5 ft. The rear end is supported by a trailing axle with wheels 55 5 in diam and the driving axle is fitted with helical springs A vacuum cylinder beneath the foot-plate applies the brake-blocks to the driving and trailing wheels

The engine has a wheel-base of 22 92 ft, and an overall length of 29 75 ft Its weight in working order is 45 15 tons, of which 17 tons rest on the driving wheels The tender in use in 1887 had six wheels 49 5 in diam, and carried 2,900 gal of water and 5 tons of coal, its weight being 33 4 tons

A working drawing of the engine is shown near Inv 1905 12 S M 9

76. MODEL OF A SIX-COUPLED GOODS ENGINE (working) Received 1892.

This represents an inside cylinder engine with six coupled wheels 4 ft diam The cylinders incline slightly downward, so that while high enough to clear the leading wheels, they act directly on the central driving axle, which has two cranks at right angles and also the four eccentrics of Stephenson's link motion The cylinder slide valves are above the cylinders, and receive their motion through a weigh shaft. The feed is supplied by a vertical flywheel donkey pump at the side of the fire-box, this model having been made before the general use of the injector The method in which three axles are coupled so that the adhesion of all six wheels is utilised for traction, is also clearly shown

The tender is fitted with six wheels and provided with a powerful hand-brake. Inv 1892-75 21059

77. MODEL OF AMERICAN LOCOMOTIVE (working). (Scale 1 : 8) Received 1880

This represents a passenger locomotive, built about 1875, for the Erie Railroad, and is of the then typical American construction, with outside cylinders, four coupled driving wheels, and a leading bogie.

The framing is of the bar type almost universally adopted in America, where its flexibility is considered to reduce the strains due to irregularities in the permanent way. The valve chests are above the cylinders, the valves deriving their motion from a weigh shaft driven by Howe's link motion from inside eccentrics. The boiler has the wagon-topped external fire-box—a distinctive feature of American practice The boiler is fed by an injector and also a feed pump driven from one crosshead. The tender is carried on two bogies, a large enclosed cab is provided for the driver and stoker, while, owing to the unprotected state of the railroad and the frequent occurrence of level crossings, a " cow-catcher " is fixed to the buffer beam , a large bell is carried on the boiler and a head lamp on the smoke-box.

Although a working model, some of the details are not to scale, but the engine would have cylinders 15 in diam by 20 in stroke, and driving wheels 56 in diam , giving a tractive factor of 80 Inv 1880–97 19601.

78. MODEL OF GOODS LOCOMOTIVE, NORTH LONDON RAILWAY. (Scale 1 : 24) Lent by E A Forward, Esq , 1902.

This represents a class of six-coupled tank locomotives designed by Mr J C Park in 1879, and subsequently constructed at the Bow Works as the standard goods engine of this suburban line.

The engine has horizontal outside cylinders, 17 in diam by 24 in stroke, and steel-tired cast iron wheels 52 in diam , so that the tractive factor is 133 Each crosshead works on a single guide-bar arranged above it, and the driving crankpin, which carries two coupling rod ends as well as the connecting rod end, side by side, is 9·5 in long The valve gear is of the usual shifting link type, but the valve rods are bent to clear the leading axle, and are suspended from the frame by links which replace the more usual guides

The boiler shell is of steel, and the barrel, which is 49 in diam , and 9·7 ft long, contains 192 steel tubes 1·75 in external diam , and 0·095 in thick The fire-box is of copper and has a grate area of 16·3 sq ft and 81 sq ft of heating surface, while the tube surface is 876 sq ft The working pressure is 160 lb per sq in , and is limited by a Ramsbottom double safety valve , a steam dome is provided, and within it the regulating valve is arranged The water is carried in a pair of side tanks, having a capacity of 950 gal , and the boiler is fed by two Gresham injectors The bunker, which holds 1 25 tons of coal, is at the rear of the foot-plate and enclosed by the cab A screw brake is provided which applies wooden blocks to the driving and trailing wheels only , sand-boxes are fitted to the leading and trailing wheels

The weight of the engine, complete in working order, is 44 tons, and this is equally distributed over the three axles The wheel-base is 11·33 ft , and the engine easily passes round curves of 5 chains radius , the overall length is 27 8 ft

Photographs of the standard goods and passenger engines of this line are shown near Inv 1902–2 S M 1354

79. MODEL OF LONDON AND NORTH WESTERN RAILWAY COMPOUND LOCOMOTIVE (working) (Scale 1 6) Received 1896. Plate VI, No 2

This shows a compound locomotive arranged on the system introduced by Mr F W Webb in 1881, but the engine represented is of a later type, known as the " Dreadnought " class, and was shown at the Inventions Exhibition in 1885

The distinctive feature of Mr Webb's arrangement is that the steam from the boiler first enters a pair of outside high-pressure cylinders acting on the trailing axle, while the exhaust from both of these cylinders passes into a single low-pressure cylinder acting on a separate axle This gives the reduced temperature ranges within the cylinders that result from compounding, and also the advantage of four driving wheels without employing coupling rods When starting it is arranged that the engine can work non-compound, the exhaust from the high-pressure cylinders passing directly into the blast pipe, and reduced boiler steam being supplied to the low-pressure cylinder

The high-pressure cylinders, 14 in diam , are arranged outside the frames between the leading and middle wheels, with long piston and connecting rods, so that they can drive the crankpins on the trailing wheels The low-pressure cylinder, 30 in diam., is on the centre line and under the smoke-box, and acts on a single crank bent in the central axle The four driving wheels are each 75 in diam., the stroke of each cylinder is 24 in., and the area of the single low-pressure cylinder is 2·3 times the combined areas of the two high-pressure cylinders. The

valve chests of the high-pressure cylinders are beneath them, and that of the low pressure is above the cylinder. The valves are all driven by Joy's gear; for the outside cylinders the reversing guides are formed in pairs of circular discs, while for the inside cylinder these guides are formed in a cast steel rocking-shaft. Both gears are reversed simultaneously from the platform by a single lever, but arrangements are provided for separate adjustment when desirable.

The leading wheels are 3ft. 9 in diam, and are carried in Webb's radiating axle-boxes, an arrangement by which on entering a curve the lateral displacement of the wheels causes an angular movement of the axle owing to the boxes being carried in a curved guide-path The rigid wheel-base is 9 ft. 8 in. and the total wheel-base 18 ft. 1 in

The boiler is of steel with a copper fire-box, and has a water bottom below the fire-bars with a small ash door in it, and a front ashpan door and damper. The grate area is 20·5 sq. ft, and the total heating surface 1,400 sq. ft The working pressure is 175 lb. per sq. in, but a relief valve prevents the steam to the low-pressure cylinder exceeding 80 lb The feed water is supplied by an injector on either side of the platform, delivering above the water level into a pipe which reaches to the middle of the barrel before it dips, so that the feed pipe is heated by the surrounding steam The tender has space for 5 tons of coal but carries only 1,800 gal of water, because it is fitted with Ramsbottom's scoop for taking up water when running (*see* No 148)

The engine is fitted with a steam brake, having a vertical cylinder 9 in. diam., which applies the blocks to the four driving wheels and to the six wheels of the tender, a hand-worked screw gear is also provided. The weight of the engine empty is 42·5 tons, and that of the tender 12 tons. Inv. 1896–85 20704.

80. PHOTOGRAPH AND DRAWINGS OF COMPOUND LOCOMOTIVE, LONDON AND NORTH WESTERN RAILWAY. Presented by F. W. Webb, Esq, 1883

These represent a class of engine which was the outcome of the experience gained with the "Experiment," the first of Webb's three-cylinder compound engines of 1881–82 The one shown, "Compound," was built in 1883 and is of slightly greater power than the earlier engine

The two high-pressure cylinders are 13 in diam, and the low-pressure cylinder is 26 in. diam, the stroke of all being 24 in The driving wheels are 79·5 in diam and the wheel-base is 17 6 ft Joy's valve gear is used for the steam distribution The total heating surface is 1,083·5 sq ft, the grate area is 17 1 sq ft, and the steam pressure is 180 lbs per sq in The weight in working order is 37·7 tons Inv 1883–398 & 399.

81. LITHOGRAPHED DRAWINGS OF LOCOMOTIVES FITTED WITH JOY'S VALVE GEAR. Lent by Messrs. David Joy & Son, 1901.

One drawing shows a four-coupled bogie engine for the Midland Railway, built at Derby in 1885 It has inside cylinders 19 in diam by 26 in stroke, and driving wheels 84 in diam, giving a tractive factor of 112 The boiler has a heating surface of 1,122 sq ft, and a grate area of 17·5 sq. ft The weight in working order is 42·8 tons

The other drawing shows a four-coupled tank engine with a radial axle at each end, built at the Stratford Works of the Great Eastern Railway in 1885 It has inside cylinders 18 in diam. by 24 in stroke, and driving wheels 64 in diam., giving a tractive factor of 121. The boiler has a heating surface of 1,054 sq. ft, and a grate area of 15·43 sq ft The weight in working order is 51·9 tons Inv. 1901–82.

82. PHOTOGRAPHS OF AMERICAN LOCOMOTIVES. Presented by Messrs. Burnham, Parry, Williams & Co., 1890.

These show four typical American locomotives, as made at the well-known Baldwin Locomotive Works which were established at Philadelphia in 1831, and illustrate types used for four different classes of service; the dimensions and leading particulars are attached to each. Inv. 1890–65.

83. PHOTOGRAPHS OF LOCOMOTIVES. Presented by Messrs. Neilson & Co., 1890.

This is a series of twenty photographs, together with the leading dimensions and particulars, of engines supplied for working the traffic in various parts of the world. Inv. 1890–62

84. PHOTOGRAPHS OF RUSSIAN LOCOMOTIVES. Presented by David Joy, Esq., 1896.

These three engines have outside cylinders, and show very clearly the arrangement of the Joy valve gear with which they are fitted

One engine has six wheels, all coupled, it weighs 34 tons empty, and 38 tons in working order The steam pressure is 132 lb per sq in, the heating surface 1,313 sq ft, the diameter of the cylinders 18·1 in, the stroke 24 in, the diameter of the wheels 55 in, and the tractive factor 143

The second engine has six wheels coupled and a four-wheeled bogie, the tender is on two four-wheeled bogies The total weight of the engine empty is 52·7 tons and 58 tons in working order The diameter of the driving wheels is 72 in., the steam pressure 147 lb per sq in, and the heating surface 1,661 sq ft The cylinders are compound and have a common stroke of 25·6 in ; the diameter of the high pressure cylinder is 19·7 in, while that of the low pressure is 28 in

The third is a four-wheel coupled engine with a leading four-wheeled bogie, it weighs 46 tons empty and 50·8 tons in working order The diameter of the driving wheels is 78 in, the steam pressure 147 lb per sq in, and the heating surface 1,571 sq ft The cylinders are compound with a common stroke of 25·6 in, the diameter of the high-pressure cylinder is 18 1 in, and that of the low-pressure 26·4 in

The large head-lights and more complete protection for the drivers are required by the local conditions, there is also a complete outside hand rail right round the sides and front of the engine Inv 1896–82.

85. DRAWINGS OF COMPOUND ENGINES ON THE NORTH EASTERN RAILWAY (Scale 1·8) Lent by T W. Worsdell, Esq, 1890

Working drawings of both a passenger engine and a goods engine, on the Worsdell and Von Borries system of compounding, are shown

In these engines two cylinders only are employed, and these are arranged within the frames To provide room for the large low-pressure cylinder, the cylinders are cast together, and are placed at different inclinations so that they overlap The valve motion is of Joy's radial type, and is reversed by a screw For starting, in cases when the high-pressure slide valve is completely closed, a starting valve is provided which shuts the communication between the high and low-pressure cylinders, and at the same time allows some live steam to enter the low-pressure cylinder

The passenger engine has cylinders 20 in and 28 in diam with a common stroke of 24 in, and single driving wheels 91·25 in diam The boiler pressure is 200 lb per sq in, grate area 20 7 sq ft, and the total heating surface 1,139 sq ft The weight of the engine in working order is 46·67 tons The slide valves are arranged on the outside of the cylinders in chests that come through the frames

The goods engine has cylinders 18 in and 26 in diam, with a common stroke of 24 in, and driving wheels 61·25 in. diam, with three axles coupled by external rods In this engine the slide valves are arranged above the cylinders The grate area is 17·23 sq ft, and the total heating surface 1,136 sq ft

Inv. 1890–135

86. MODEL OF EXPRESS LOCOMOTIVE OF THE LONDON AND SOUTH WESTERN RAILWAY (working). (Scale 1:8.) Made by Messrs. T. & C. J. Coates, 1896 and 1899. Plate VII, No. 1.

The engine and tender represented were designed and constructed at Nine Elms in 1890, by Mr. W. Adams, for working the express passenger traffic on the London and South Western Railway.

The cylinders are 19 in. diam. by 26 in. stroke, and act on four coupled driving wheels 85 in. diam., exerting a tractive effort of 110 lb. per lb. of effective mean pressure in the cylinders. Each piston rod is guided by a single bar guide arranged vertically over it, and in some engines of this class the piston rod was extended through the cover as a tail rod The valve gear is of the usual shifting link construction, giving a cut-off varying from 75 per cent. with full gear to 17 per cent in usual running condition, it is controlled from the footplate by a reversing screw. The regulator or main steam valve is of the vertical sliding type, and is arranged in a steam dome, at its back is a smaller valve which, opening first, reduces the frictional resistance of the main one

The boiler shell and the external fire-box are of mild steel, but the internal fire-box is of copper The tubes are of brass, 1·75 in. outside diam, and 240 in number. The grate area is 18 sq. ft, fire-box surface 122 sq ft, and tube surface 1,244 sq. ft To ensure complete combustion the fire-box is fitted with a brick arch and a deflector. The grate bars are of cast iron in two lengths The blast pipe is of Mr Adams's "vortex" construction with an area of 14 sq. in (*see* No 115) The safety valves, loaded to 175 lb per sq in, are of Ramsbottom's double type, with an easing lever extending to the cab. The feed water is supplied from the tender by two injectors, and the engine is fitted with a steam and an automatic brake. The front of the engine is carried on a four-wheeled bogie, with wheels 45·75 in diam, the engine and bogie frames are of mild steel plate The springs of the driving and trailing axles are connected by equalising levers The total weight of the engine in working order is 48·75 tons

The tender is carried on six wheels and has double frames with outside bearings, the wheel-base is 13 ft and the wheels are 45 75 in diam The brake of the tender is applied by a vertical steam cylinder or by a screw, the screw rod rising in its guides when the brake is forced on by steam pressure The water tank has a capacity of 3,300 gal, it is fitted with vertical and horizontal tie-bars and angles to give the necessary rigidity, while the supply orifice is provided with a deep strainer which acts as a baffle plate in preventing the upward splash of the water The tender is coupled to the engine by a central draw-bar and two loose side links, and here there are also two special buffers, at the front end of the tender is a sand box and tool chest, also a hinged door for closing the opening through which the coal from the top of the tender is raked on to the footplate The weight of the tender empty is 14·3 tons, and it carries 3 tons of coal and 14·7 tons of water

The total weight of the engine and tender in working order is 80·75 tons, and the normal weight of the train behind them is about 230 tons

Inv 1896–81 20,881, 2 & 3

87. PHOTOGRAPHS AND DRAWINGS OF TANK LOCOMOTIVES. (Scale 1 . 32) Presented by T Hurry Riches, Esq., 1898 and 1908

The earlier of these engines were designed by Mr Riches in 1890 for the Taff Vale Railway

The passenger engine has inside cylinders 17·5 in diam by 26 in stroke, and four coupled wheels 63 in diam, giving a tractive factor of 127 There is a leading four-wheeled bogie, and a pair of trailing wheels with their axle in radiating boxes. The boiler has 19 sq ft of grate, and 1,042 sq ft of heating surface; the working pressure is 160 lb. The tank carries 1,500 gal of water and the bunker 1·5 tons of coal The weight of the engine empty is 45 tons, and in working condition 57 tons

The mixed-traffic engine has similar cylinders and driving wheels, it is however, six coupled, and has a radiating trailing axle, but no bogie Its weight empty is 52 tons, and 64 tons when full

The later photograph shows a mixed-traffic engine, designed by Mr Riches in 1908. It has inside cylinders 17 5 in diam by 26 in stroke, and six coupled wheels 54·5 in diam, giving a tractive factor of 146 There is a radiating trailing axle with wheels 37 in diam The boiler has a heating surface of 1,301 sq ft, of which the fire-box has a 107 sq ft The grate area is 21 sq. ft

Inv 1898–41, & 1908–39.

88. PHOTOGRAPH OF AMERICAN EXPRESS LOCOMOTIVE. Presented by Harold Edwards, Esq., 1899.

This shows the leading features of the modern American locomotive, in which the bar frame and outside cylinders with valve chests above them are almost invariably adopted, the front of the engine is fitted with a powerful track clearer

or cow-catcher, and the large head-light and bell are added on account of the railroad not being completely enclosed.

The engine represented, No. 999 of the New York Central and Hudson River Railroad, was shown at the Chicago Exhibition in 1893, and was stated to have travelled a distance of one mile in 32 sec ; this would be at the rate of 112·5 miles an hour. It has two cylinders 19 in. diam by 24 in stroke, and driving wheels 86 in. diam., giving a tractive factor of 100 ; there are four coupled driving wheels, and a leading four-wheeled bogie with wheels 40 in. diam. The boiler has 260 tubes, 2 in. diam. and 12 ft long, giving nearly 1,700 sq ft. of surface, while the heating surface in the fire-box is 233 sq ft The total heating surface is nearly 2,000 sq ft. and the grate area 30·7 sq. ft. The inside diameter of the chimney is 15·25 in , and its top is 14·8 ft above the rails. In working order the weight of the engine is 55·3 tons and that of the tender 35·7 tons, the total running weight of engine and tender being 91 tons. Inv. 1899–2.

89. DRAWING OF BALDWIN LOCOMOTIVE. (Scale 1 . 16.) Presented by Clement E. and C. Stretton, Esqs , 1900.

This is a passenger locomotive on the Vauclain system of compounding, fitted with the extended fire-box introduced in 1878 by Mr, J E. Wootten for burning anthracite coal It was built at the Baldwin Works in 1893, for the Philadelphia and Reading Railroad, and has attained a speed of 82 miles an hour.

On each side there is a pair of cylinders, 13 in and 22 in diam by 24 in stroke, with a common crosshead and connecting rod , there are four coupled driving wheels 78 in diam , while the smaller wheels are 48 in diam.

The boiler barrel is 57·5 in diam and contains 324 tubes 1·5 in. diam. by 10 ft. long , the fire-box is 9·5 ft. long by 8 ft. wide, with a grate area of 76 sq. ft., and has 173 sq. ft. of heating surface, the total heating surface of the boiler being 1,435 sq ft Owing to the non-flaming character of the fuel employed, fire-box surface has to be chiefly relied on, and an exceptional area of grate is necessary ; these requirements are met by raising the grate above the level of the trailing wheels and by spreading it to the full width of the engine The grate surface is formed by water-tubes and fire-bars alternately, and there is a separate combustion chamber. The firing platform is at the end of the boiler, but the driving cab is arranged on the sides of the barrel The total weight of the engine in working order is 58·8 tons Inv 1900–13.

90. PHOTOGRAPHS OF WINBY'S LOCOMOTIVE. Presented by Messrs. R. and W Hawthorn, Leslie & Co , 1893

Three views are shown of the engine " James Toleman," designed by Mr. F C Winby, and constructed in 1893 by Messrs Hawthorn, Leslie & Co It has two inside cylinders 17 in diam by 22 in stroke, and two outside cylinders 16 5 in diam by 24 in stroke , the total tractive factor is therefore 143·3 There are two pairs of driving wheels each 90 in diam , and no coupling rods, as each pair of cylinders drives one axle The boiler is peculiar, the barrel not being circular, and the grate extending much further forward than the crown of the fire-box, but the grate area is 28 sq ft , and the total heating surface 2,000 sq ft , the boiler pressure is 175 lb per sq in The total weight in working order is 61 tons Inv. 1893–174.

91. MODEL OF EXPRESS PASSENGER LOCOMOTIVE OF THE NORTH BRITISH RAILWAY. (Scale 1 16) Presented by R. St J Willans, Esq , 1902

This represents a class of four-coupled bogie locomotives designed about 1895 by Mr. Matthew Holmes, and built at the Cowlairs Works, Glasgow.

The engine has horizontal inside cylinders 18 in. diam by 26 in stroke and driving wheels 84 in diam , thus giving a tractive factor of 100 The valves are placed between the cylinders and worked by the usual shifting link reversing gear controlled from the left hand side of the cab by a vertical screw.

The boiler barrel is 53·5 in. diam. by 10·3 ft. long, and contains 238 tubes 1·75 in. diam. The total heating surface is 1,266 sq. ft , of which the fire-box forms 118 sq. ft., and the grate area is 20 sq ft. The working pressure is 150 lb., and it is limited by a pair of safety valves placed on top of the dome and directly loaded by springs.

The front of the engine rests on a bogie having four wheels 42 in. diam.; the total wheel-base of the engine is 22·42 ft., of which 9·33 ft. is rigid. The engine is fitted with the Westinghouse brake applied by means of cylinders suspended between the driving and trailing wheels. The weight of the engine in working order is 46·5 tons, of which 31 tons rest on the coupled wheels.

The tender is mounted on six wheels 48 in. diam. with a 12 ft. wheel-base; it has outside frames and carries 2,500 gal. of water, while its weight in working order is 32 tons. The total weight of engine and tender in working order is 78·5 tons and the overall length 52·7 ft.

In front of the model is shown a grooved pulley which was at one time used in connection with an endless wire rope employed in assisting trains up the incline from Queen St station to Cowlairs. Inv. 1902-9.

92. DRAWING OF EXPRESS LOCOMOTIVE OF THE LONDON AND SOUTH WESTERN RAILWAY. (Scale 1 : 12) Lent by Messrs Dubs & Co, 1901.

This is an example of a class of express locomotive designed by Mr. D Drummond in 1898, and built by Messrs Dubs & Co It has inside cylinders 18·5 in diam by 26 in stroke, driving four coupled wheels 79 in diam, so that its tractive factor is 112

The slide bars, of which there are four to each cylinder, are entirely supported by a central spectacle plate, which also contains the guides for the valve rods The valves, which work in a single steam chest between the cylinders, are each made in two parts placed side by side, but have separate ports, and the exhaust of the lower ones pass downward and round the outside of the cylinders The valve gear is of the usual shifting link type, but is reversed by a steam cylinder checked by an oil cataract and controlled by a small hand lever in the cab

The boiler barrel is 4·5 ft diam by 10·5 ft long, and contains 280 brass tubes 1·5 in external diam The internal fire-box is of copper, and has a curved roof supported by bolts from short brackets suspended from girders riveted to the external crown The upper portion of the fire space of the box is fitted with an arrangement of water tubes, patented in 1897 by Mr Drummond, in which straight solid-drawn steel tubes 2·75 in external diam and 0 125 in thick are employed These are arranged transversely in two groups, the front one thirty-six tubes and the back one of twenty-five, inclining in opposite directions at 5 deg with the horizontal Their ends are specially expanded into the fire-box plate, and opposite the ends of each group are large inspection holes through the fire-box shell, closed by hinged doors bolted to cast steel seats and strengthened by internal stays passing through some of the tubes from door to door These water tubes present 165 sq ft of heating surface, while that of the fire-box plating is but 148 sq ft, the total heating surface in the boiler is 1,500 sq ft and the grate area 24 sq ft, the working pressure is 175 lb per sq in The smoke box is fitted with Mr. Drummond's spark arrester, which consists of a chimney tube, extending down to the top of the blast pipe and having openings in it at the sides and front, into which the gases are directed by baffle plates The feed water, which is supplied by two injectors at the side of the ash-pan, is passed through pipes in the smoke-box before entering the boiler

The engine is supported at the front end by a bogie having four wheels 48 in diam at 6·5 ft centres, the rigid wheel-base of the engine is 10 ft and its total wheel-base 23·25 ft while its weight is 50 4 tons, of which 35 4 tons are carried by the coupled wheels:

The tender has six wheels 48 in diam and a wheel-base of 14 ft, but some of these engines are provided with tenders carried on double bogies, the capacity of the tender is 3,500 gal of water and 4 tons of coal

The total weight of engine and tender in working order is 91·1 tons, and the overall length is 56 ft Inv 1901-117.

93. PRINT OF AMERICAN-BUILT LOCOMOTIVE FOR THE MIDLAND RAILWAY. Presented by C. E. Stretton, Esq, 1899

In 1899 considerable sensation was caused by some of the English railway companies ordering locomotives from America, owing to a great increase of the traffic having created a sudden demand for more motive power than the existing manufacturing arrangements on this side of the Atlantic were, under exceptional circumstances, able to meet. The action was not unprecedented, because in 1840 several American locomotives were imported for use on the Birmingham and Gloucester Railway (*see* No. 56), and in our Colonies a considerable number of American engines have long been used.

The engine represented is the first of a batch of thirty ordered from the Baldwin Locomotive Works for the Midland Railway Co., and it generally represents American practice with only slight modifications to meet English requirements. The engine is of the "Mogul" type with outside cylinders 18 in. diam. by 24 in. stroke and six coupled wheels 60 in. diam., so that its tractive factor is 129; the leading wheels are 33 in. diam. and are carried in a pony frame. The rigid wheel-base is 14·75 ft. and the total wheel-base 22·17 ft. The framing is of the American bar type, and the cab gives much more protection from the weather than the usual English construction; the slide valves are balanced and are driven by the ordinary link motion, through the intervention of rocking shafts.

The boiler shell is 56 in diam. and of 0·625 in. steel plate, the fire-box and stays are of copper. There are 263 tubes 1·75 in. diam., giving 1,247 sq. ft. of heating surface, and the total heating surface is 1,372 sq. ft., the grate area is 16·6 sq ft. and the working pressure 180 lb. The tender is carried on two four-wheeled bogies and has a capacity of 3,000 gal The weight of the engine is 44·75 tons and that of the engine and tender 80·15 tons Inv. 1899–17.

94. LITHOGRAPHS OF LOCOMOTIVES. Presented by the Locomotive Publishing Co., Ltd., 1901.

These coloured lithographs represent express passenger locomotives used on eight different British railways. Inv. 1901–18.

95. MODEL OF COMPOUND LOCOMOTIVE, WESTERN RAILWAY OF FRANCE (working). (Scale 1 : 10) Made by M. P. Regnard. Received 1903 Plate VII, No. 2

This represents a powerful passenger locomotive designed by M. Clerault and constructed at the Batignolles works of the railway company in 1901. It has four cylinders, six coupled wheels and a leading bogie arranged in a manner introduced in 1885 by M de Glehn and modified in 1891 by M du Bousquet

The engine is of the compound type, as the steam from the boiler first enters a pair of outside high-pressure cylinders acting on one axle and is then exhausted into a pair of low-pressure cylinders acting on a separate axle which is, however, coupled to the first The cranks of the adjacent high and low-pressure cylinders are placed at 180 deg with each other, so that the reciprocating masses move in opposite directions and thus nearly balance their inertia stresses while the rotating masses are completely balanced by weights in the wheels Each cylinder is provided with a separate valve gear, and there are additional starting valves by which the engine can be worked non-compound, the exhaust from the high-pressure cylinders then passing directly into the blast pipe, while reduced steam direct from the boiler is supplied to the low-pressure cylinders. By these arrangements the economy due to compound working is obtained, with good balancing, while, owing to the reduction in the stresses through the work done being divided over four cylinders, it is claimed that the increased amount of mechanism entails no extra wear

The high-pressure cylinders, 13 77 in diam., are arranged outside the frames immediately in front of the coupled wheels, and act on the crankpins of the second pair of these wheels, the low-pressure cylinders, 21·56 in diam., are placed between the frames under the smoke-box and act on a crankshaft carrying the leading pair of coupled wheels The low-pressure cylinders with their valve chest and the boiler cradle are in one casting secured between the frames, while the external high-pressure cylinders are stayed together between the frames by a special casting which also assists in carrying the guide bars The stroke of both cylinders is 25·2 in. and the area of the low-pressure cylinder is 2·47 times that of the high-pressure, the driving wheels are all coupled and 76·4 in. diam.

The valve chests of all the cylinders are placed above them, those of the low-pressure, however, inclining outward, the valves are of the ordinary flat type and those of the inside cylinders are driven by the Walschaerts motion, in which a single eccentric is used for each cylinder, while those of the outside cylinders are driven by the same gear, but with a return crank in place of the eccentric, these gears can be linked up either together or separately by means of a screw reversing gear

The valves for separating the high- and low-pressure cylinders when starting are placed on the high-pressure exhaust pipes and are actuated by a small compressed air cylinder beneath the boiler barrel, while the steam pressure in the low-pressure chest is limited by a relief valve to 85 lb. per sq. in., the boiler pressure being over 200 lb.

The bogie has four wheels, 37·8 in. diam., with a wheel base of 6·56 ft. and is arranged to permit of sliding lateral displacement. The rigid wheel-base of the engine is 14·11 ft. and its total wheel-base 26·92 ft.; the gauge of the rails is the standard 4·7 ft.

The boiler is of steel, with a copper fire-box, and has a barrel 57 in. diam. by 14·63 ft. long between tube plates. The fire-box is of the Belpaire type, in which the outer shell and the fire-box crown are both flat and directly tied together by screwed stays, while long transverse stays connect the flat sides of the upper part of the outer shell By this method of staying, the usual girder stays are entirely dispensed with and increased steam space is obtained. The back plate of the external fire-box is directly tied to the boiler barrel by longitudinal stays, the number of which is, however, reduced by the addition of heavy stiffening ribs riveted to the flat surfaces. The boiler is provided with 113 tubes of 2·75 in external diam, but as these are of the internally ribbed type, patented by M. J. P. Serve in 1885 (*see* No 130), their total internal surface is 2,149 sq. ft. although their external surface is but 1,217 sq ft. The tubes are fitted by expanding in the usual manner after the ribs have been cut away near the ends, and they are cleaned after use by a steam jet assisted by occasional scraping

The grate slopes forward and, to facilitate cleaning, has a hinged dropping portion at the lower end operated from the footplate The grate area is 26·4 sq ft. and the heating surface of the fire-box 131 sq ft There is a steam dome containing the regulator, which is of the vertical slide type with a smaller starting slide, and there are two directly loaded safety valves upon the fire-box which limit the steam pressure to 213·3 lb per sq in The smoke-box is long and has an ash-shoot below; the blast-pipe is provided with a nozzle which is adjustable by two hinged flaps worked from the footplate The chimney expands within the smoke-box into a conical chamber, the bottom of which is formed by a large spark-arresting grating provided with an orifice for the blast

The feed water is delivered by a pair of injectors placed on the back of the fire-box, Gresham's sanding apparatus, using compressed air, is provided for the wheels, and continuous lubrication is effected by a pump driven by the valve gear A special fitting is attached to the boiler with which the several small steam pipes are connected, thus reducing the number of holes made through the boiler shell The total weight of the engine in working order is 62·5 tons, of which 44·3 tons are available for adhesion

The tender has six wheels, 44·5 in diam, spread over a wheel-base of 10·5 ft, and the springs of the two rear axles are connected by compensating levers, so that the whole load is equally distributed over the six wheels The tender carries 3,300 gal of water and 5 tons of coal, and its weight in working order is 36 5 tons

The coupling between the engine and tender is of the Roy construction tightened up by a ratchet on the screw, oblique cheeks are secured to the tender while the corresponding pieces on the engine form portions of a spherical surface, so that when tightened up the connection possesses flexibility while it restricts the longitudinal and lateral movements The engine is fitted with the Westinghouse brake apparatus, and has air brakes on the six coupled wheels, the wheels of the tender are similarly fitted, but their brakes can be applied by hand if required

The total weight of the engine and tender in working order is 99 tons, and their overall length is 56·3 ft Inv 1903–9 27,887 & 27,888

96. PHOTOGRAPHS OF GREAT WESTERN RAILWAY LOCOMOTIVES Presented by A Davidson, Esq, 1906.

One of these prints represents a single-driving express passenger engine designed by Mr W Dean in 1892 The cylinders are 19 in. diam by 24 in. stroke and the driving wheels 92 in diam, giving a tractive factor of 94·2 The boiler contains 266 tubes of 1·75 in diam, providing 1,434 sq ft of heating surface, the fire-box has 127 sq ft of heating surface and a grate area of 20·8 sq. ft The steam pressure is 160 lb. per sq in The engine has a wheel-base of 23·5 ft of which only 9 ft are rigid, its weight in working order is 49 tons, 18 tons of which rest on the driving wheels The tender carries 3,000 gal of water The total weight of engine and tender in working order is 81·5 tons, and the overall length is 57·65 ft

The other print represents a class of four-coupled bogie engines built to the designs of Mr G. J. Churchward in 1903 The cylinders are 18 in. diam. by 26 in. stroke, and the driving wheels 80·5 in. diam, giving a tractive factor of 105. The boiler has a conical barrel and a Belpaire fire-box; it contains 350 tubes of 1·625 in. diam, providing 1,690 sq ft of heating surface; the fire-box has 128 sq. ft of heating surface and a grate area of 20·56 sq. ft The steam pressure is

200 lb. per sq. in. The engine has a wheel-base of 22·5 ft. of which only 8·5 ft. are rigid; its weight is 55·3 tons, 36·1 tons of which rest on the coupled wheels. The tender is fitted with water-pick-up apparatus, and carries 3,000 gal. of water and 4 tons of coal The total weight of engine and tender in working order is 92·05 tons. Inv. 1906–8.

97. PHOTOGRAPHS OF SHORT MOTOR TRAIN. Presented by T. Hurry Riches, Esq., 1908.

These photographs show an arrangement now being adopted where the traffic is somewhat heavier than can be provided for by rail motor cars consisting of a single vehicle

The train shown was constructed for the Taff Vale Railway in 1908; it consists of two cars of the type usually adopted, with an ordinary tank locomotive placed between them, arrangements are made, however, by which the train can be driven in either direction, so that terminal shunting is avoided. A driver's compartment is formed at either end, and is provided with fittings for operating the engine regulator and whistle and the automatic and hand brakes The fireman attends to the boiler and the reversing gear The locomotive used was built in 1884, it has outside cylinders 16 in diam by 24 in stroke, and four-coupled wheels 63 in diam, giving a tractive factor of 97·5; it has a bogie at the leading end The carriages are supported on two four-wheeled bogies, and they have accommodation for first and third class passengers Inv 1908–39

98. PHOTOGRAPHS OF GREAT NORTHERN RAILWAY LOCOMOTIVES Presented by the Great Northern Railway Co., 1911

One of these prints represents an express passenger engine of the 4–4–2 or "Atlantic" type, built in 1908, and belonging to a class introduced by Mr H A Ivatt in 1903 The cylinders are 18 75 in diam by 24 in stroke, and the driving wheels 80 in diam, giving a tractive factor of 105·5 The boiler barrel contains 248 tubes of 2·25 in diam which provide 2,359 sq ft of heating surface, the fire-box is spread out over the main frames to a width of 6 75 ft, and has 141 sq ft of heating surface and a grate area of 30·9 sq ft The steam pressure is 175 lb per sq in The engine has a wheel-base of 26 33 ft of which only 6 83 ft is rigid, the bogie and trailing wheels are 44 in. diam The engine weighs 65 5 tons, 36 tons of which rest on the coupled wheels The tender carries 3,670 gal of water and 5 tons of coal The total weight of engine and tender in working order is 106·4 tons, and the overall length is 57·85 ft

The other print represents a class of four-coupled bogie passenger engines built to the designs of Mr H A Ivatt in 1911 The cylinders are 18 5 in diam. by 26 in stroke, and the driving wheels 80 in diam, giving a tractive factor of 111. The boiler is fitted with the Schmidt superheater, which has a heating surface of 258 sq ft, while the ordinary tube surface is 852 sq ft, the fire-box has 120 sq ft of heating surface, and a grate area of 19 sq ft The steam pressure is 160 lb per sq in The engine has a wheel base of 22 12 ft of which 9 ft are rigid, its weight is 53·3 tons, 35·5 tons of which rest on the coupled wheels The tender is fitted with water pick-up apparatus, and carries 3,500 gals of water and 6·5 tons of coal The total weight of engine and tender in working order is 96 4 tons, and the overall length is 52 94 ft Inv. 1911–75 & 76.

99. PHOTOGRAPHS OF LOCOMOTIVES Lent by the Great Western Railway Co, 1911

This series shows twelve modern locomotives employed on this line Six types of express passenger engines, two types of passenger tank engines, and four types of goods engines are shown All are fitted with superheaters, and the principal dimensions are given on each photograph. Inv 1911–82 to 93

100. LOCOMOTIVE CHARTS. Presented by the Locomotive Publishing Co, Ltd., 1907, 1915 and 1922.

These nine sectional diagrams show clearly the construction of different types of locomotives for various railways.

Inv 1907–9; 1915–349, 350, 1922–114 to 117, 120, 121.

101. PHOTOGRAPH OF EXPRESS PASSENGER LOCOMOTIVE. Presented by the London Midland and Scottish Railway Co., 1922.

This shows a four-cylinder simple engine of the 4–6–0 type, designed by Mr. C. J Bowen Cooke and built at Crewe works in 1913.

The cylinders are 16 in. diam. by 26 in stroke, and the driving wheels 81 in. diam., giving a tractive factor of 164·4. Walschaërts gear is fitted to the outside piston valves, while the inside valves are driven from them by rocking levers. The boiler is fitted with a Schmidt superheater, the total heating surface being 2,232 sq ft. and the grate area 30·5 sq. ft. The steam pressure is 175 lb. per sq. in. The bogie wheels are 39 in diam., and the rigid wheel-base of the engine is 15·25 ft.; the weight on the driving wheels is 58·5 tons. The tender runs on six wheels and carries 3,000 gal of water and 6 tons of coal. The total weight of engine and tender in working order is 117 tons and the overall length is 63·4 ft.

An engine of this class, when hauling the Scotch Express weighing 360 tons, developed nearly 1,700 horse-power at a speed of 69 miles an hour, the draw-bar pull at the time being 2·625 tons. Inv 1922–263.

102. DRAWINGS OF THREE-CYLINDER UNIFLOW LOCOMOTIVE. (Scales 1 : 4 and 1 : 8) Presented by the London and North Eastern Railway Co., 1920

These show an Atlantic type express locomotive, designed by Sir Vincent L. Raven, and built at Darlington in 1919 It has three cylinders, 16·5 in diam by 26 in stroke, arranged to work on the uniflow system which had been previously tried on a two-cylinder mixed-traffic engine in 1913 The uniflow engine was patented by Jacob Perkins in 1827 and reintroduced by Mr L J. Todd in 1885, the object being to minimise the initial condensation due to the recurring variations in the temperature of the cylinder walls. The system was revived by Prof J. Stumpf in 1908, and applied to several locomotives built on the Continent. Theoretically the uniflow system gives the advantages of compounding, without receiver losses, and is simpler and cheaper

In this form of engine the exhaust ports are arranged in a belt round the middle of the cylinder, the same ports serving for both ends, while the piston is of such a length that the exhaust ports are covered by it except at the end of each stroke This involves increased length of the cylinder also The valves are of the piston type with outside admission, and they admit steam to the ends of the cylinder and control the cut-off in the usual way The steam then expands and cools, and passes straight through the exhaust ports which open at 0·9 of the stroke On the return stroke the exhaust ports close early and the steam remaining in the cylinder is compressed, but the clearance is made large enough to obviate excessive pressures during normal working Provision, however, has to be made for relieving this back pressure when working with a late cut-off, and under these conditions the increased travel of the piston valves permits a partial exhaust through the admission ports The valves are placed above the cylinders and are driven by three independent sets of Howe link motion all located between the frames The three cranks are set at 120 deg to one another.

The four coupled driving wheels are 82 in diam., giving a tractive factor of 129·5 The boiler barrel is 66 in diam and 15·9 ft long, it contains 90 tubes of 2 in diam and 24 superheater elements, the total heating surface being 2,006 sq ft, to which the fire-box contributes 180 sq ft The grate area is 27 sq ft The engine has a wheel-base of 29·75 ft of which only 7·58 ft is rigid, the bogie wheels are 37·25 in diam and the trailing wheels 48 in diam The engine weighs 79·2 tons in working order, 39·85 tons of which rest on the coupled wheels The tender runs on six wheels with a wheel-base of 12·66 ft It carries 4,125 gals of water, 4·5 tons of coal, and weighs 46·6 tons in working order. The total weight of engine and tender is 125·8 tons and the overall length is 64·28 ft. Inv. 1920–75.

103. PHOTOGRAPH OF THREE-CYLINDER LOCOMOTIVE, GREAT NORTHERN RAILWAY. Presented by the Locomotive Publishing Co., Ltd., 1922.

This represents one of ten 2–6–0 mixed-traffic locomotives designed by Mr. H. N Gresley, the first of which was put into service in March 1920.

The three cylinders are 18·5 in diam. by 26 in. stroke, and the driving wheels 68 in. diam., giving a tractive factor of 208, or a tractive effort of 30,000 lb. with

80 per cent. of the boiler pressure. The three cranks are all on the middle coupled axle and they are set nearly at 120 deg with one another. The piston valves have inside admission, the outside valves being directly driven by Walschaerts valve gear, and the inside valve, through a system of levers, by the outside valve spindles (*see* No 126).

The boiler barrel is formed of one plate and is 6 ft. diam. and 11·46 ft. long; it contains 217 tubes of 1·75 in outside diam, giving 1·192 sq. ft. of heating surface, a 32 element Robinson superheater, giving 527 sq ft, while the fire-box gives 182 sq ft, so that the total direct heating surface is 1,901 sq ft The superheater furnishes an additional 407 sq ft The grate area is 28 sq. ft and the steam pressure is 180 lb per sq. in

The engine has a wheel-base of 25·17 ft of which the coupled wheels cover 16·25 ft The leading wheels are 38 in diam The engine weighs 71·7 tons, 60 tons being equally divided between the coupled wheels The tender carries 3,500 gal. of water and 6·5 tons of coal It weighs 43·1 tons The total weight of engine and tender in working order is 114·8 tons, and the overall length is 57·48 ft.

Inv 1922–112

MOUNTAIN LOCOMOTIVES.

104. MODEL OF FELL CENTRE RAIL LOCOMOTIVE (working). (Scale 1 16) Made from drawings prepared in the Museum, 1904

The use of a central rail and horizontal gripping wheels to increase the adhesion of a locomotive running on smooth rails was first proposed and patented in 1830 by Messrs C B Vignoles and J Ericsson, while the system was re-invented in 1847 by Mr G E Sellers, who tried it practically in America The project was revived, however, during the construction of the Mont Cenis tunnel, when Mr J B Fell proposed that a railway on the "central rail" system should be built over the pass, and in 1863–69 he secured patents for such locomotives After experiments had been carried out on the Cromford and High Peak Railway and at Mont Cenis, the line was constructed and opened in 1868, but it was not financially successful, and its life ended on the opening of the tunnel in 1871 The railway was 48 miles in length, laid along the public road to a gauge of 3·61 ft. (1·1 m), having a maximum gradient of 1 in 12 with a minimum radius of curvature of 2 chains, the central rail was laid on all gradients steeper than 1 in 25 The system was afterwards tried in Brazil. In 1879 an incline of 1 in 15 was constructed in New Zealand and successfully worked.

The model represents the framework and gearing of one of the Mont Cenis engines built in 1867 by Messrs Gouin & Co, Paris, it is shown mounted on a gradient of 1 in 12

The engine was carried on four-coupled wheels 28 in diam with a wheel-base of 7·08 ft There were two horizontal cylinders 16 ins diam by 16 in stroke, fixed between the frames in the usual way, with the valve chests between them The valves were driven by outside eccentrics, link motion, and rocking shafts The tractive factor was 146·3 At the middle of the engine, between a pair of transverse stays, were situated two sliding frames, one on each side of the centre line; each of these carried two vertical shafts, having at their upper ends overhung cranks, while to their lower ends were fixed the horizontal wheels, 28 in diam, which were pressed inward so as to grip the central rail, by means of springs and cross-beams actuated by a right and left hand screw operated from the footplate. The shafts on each side of the central rail were coupled by rods at the top and bottom, and were directly driven by the pistons through connecting rods moving in a horizontal plane, while the motion was communicated to the carrying wheels through rocking shafts and levers which drove outside connecting rods attached to crank pins in the wheels. In later engines, however, it was found necessary to couple the horizontal wheels on opposite sides of the central rail by linkwork or spur gearing, so as to keep them in correct phase with one another The boiler had a barrel 3 ft. diam, and 9·33 ft long, with a heating surface of 654 sq. ft, and a grate area of 13·5 sq. ft.; the steam pressure was 120 lb. per sq. in. When descending inclines the engine was retarded by brake-blocks on the carrying wheels and also by means of slipper blocks gripping the central rail.

The weight of the engine in working order was about 20 tons, while a similar pressure could be applied to the central rail, thus doubling the adhesion; in general working the engine hauled a load equal to its own weight up a gradient of 1 in 12 at a speed of 10 miles an hour. The double-headed central rail was laid on its side and supported on chairs formed of bent wrought iron bars which were bolted to longitudinal sleepers laid upon and secured to the transverse ones.

A photograph of one of the engines used on the New Zealand line is shown in No. 83. Inv. 1904-20. 29309

105. MODEL OF RIGGENBACH RACK LOCOMOTIVE (working). (Scale 1 : 16.) Made from drawings prepared in the Museum. 1904.

The rack and pinion as a means of locomotive haulage was patented in 1811 and used in 1812 by John Blenkinsop (*see* No 10) In 1852 the system was revived with a central rack and applied to an incline of 1 in 16·5 at Madison, U S A In 1857 Mr. S Marsh proposed a similar line with a maximum gradient of 1 in 3 at Mount Washington, U S A, and this was constructed in 1869 The system was taken up in Europe by Mr N. Riggenbach, who patented improved appliances in 1862, in 1870 he constructed the Rigi railway in Switzerland, which has a maximum gradient of 1 in 4; this was followed by several others, one of which runs up the Kahlenberg, near Vienna This line, which was constructed in 1874, was laid to a gauge of 4·71 ft and had a maximum gradient of 1 in 10, the ladder rack was laid midway between the rails The model represents the framework and gearing of one of the locomotives built for this line at the Swiss Locomotive Works, Winterthur It is shown mounted on a 10 per cent incline

The engine was carried on four wheels, 26 in diam, with a wheel-base of 10·17 ft There were two horizontal outside cylinders 13 in diam by 17·72 in stroke, which drove a countershaft having a pair of pinions fixed on it, below this was a shaft carrying a toothed wheel which geared with the rack, and to each side of it was bolted a wheel gearing with the pinion above The tractive factor was 173 The boiler was of the ordinary locomotive type with a heating surface of 582 sq ft and a grate area of 10·6 sq ft, the steam pressure was 132 lb per sq in

The engine with its chimney at the lower end, pushed the carriages up the incline, there being no couplings The descent was regulated by three methods of braking (*a*) by a strap brake on one of the crank discs, (*b*) by a toothed pinion on the back axle gearing with the rack and fitted with drums and brake-blocks, (*c*) by the compression in the cylinders of air from the outside, drawn through the exhaust ports and expelled through a special regulating valve Guards were provided to prevent derailment The engine carried 220 gal of water in tanks and 25 cwt of coal in bunkers, its weight in working order was 19·44 tons and its ordinary load 42 tons

The permanent way consisted of flat-footed rails weighing 40 lb per yd., spiked to transverse sleepers The rack had a pitch of 3·72 in, the teeth being formed of wrought iron bars of trapezoidal section with oval ends riveted into the webs of a pair of 4 in. by 2·4 in. channel irons, placed back to back 5 in apart The rack was in lengths of about 10 ft joined by fish plates and bolted to the sleepers its weight was 111 lb per yard

An adjacent print shows the complete engine Inv. 1904-21 29310.

106. MODEL OF ABT RACK LOCOMOTIVE (working). (Scale 1 · 16.) Made from drawings prepared in the Museum, 1904

The Riggenbach ladder rack as used on most of the early mountain railways had several defects, and to overcome these Mr R Abt patented in 1882 an improved form of rack consisting of narrow rectangular bars having teeth cut in them, and placed vertically on chairs These bars were arranged in two or three lines near together with the teeth stepped, and a pair of stepped pinions on the locomotive, out of phase with one another, geared into them, thus ensuring smoothness of motion. The first railway on this system was constructed in 1884-86 at Blankenburg in the Harz Mountains and the system has since received wide application In 1894-96 a tourist line was constructed on Mount Snowden, it is 4·67 miles long with a rise of 3,140 ft., its average gradient being 1 in 7·83 and the maximum gradient 1 in 5·5, the gauge is 31·5 in. and the minimum curve is of 4 chains radius. The model represents the framework and gearing of one of the locomotives built at the Swiss Locomotive Works, Winterthur, for use on this line, together with the permanent way on a gradient of 1 in 5·5.

The engine is carried on six wheels ; the four leading ones are 25·71 in. diam., running loose on their axles ; the trailing wheels, 20·47 in. diam , are arranged on a Bissell truck ; the rigid wheel-base is 4·43 ft. and the total 9·85 ft There are two horizontal outside cylinders, 11·81 in. diam. by 23·62 in stroke, placed above the foot-plate midway along the engine, with the valve chests above them. The piston rods are continued forward to the crossheads and the motion is communicated to cranks on the central axle through connecting rods and rocking levers pivoted low down on the frame The two leading axles are coupled by rods and each carry a double pinion gearing with the rack , these consist of toothed rings, connected with discs forged solid with the axle by means of internal springs allowing a slight circumferential movement, thus compensating for any irregularities in the rack teeth Each pinion has fifteen teeth and a pitch diameter of 22·56 in , the teeth of one pinion ring being opposite the spaces of the other The tractive factor is 1·46. The pinions are held in position laterally by grooved brake drums on each side bolted to the axle discs. The engine frames are outside the wheels and are strongly braced by vertical and horizontal cross stays , springs are provided at the driving and trailing wheels only The boiler has a heating surface of 397 sq ft and a grate area of 10 sq ft , its axis is inclined at 1 in 11 to the rails , the steam pressure is 200 lb per sq in

The engine pushes its load up the inclines, there being no couplings, whilst on the descent three methods of braking are available These consist of (*a*) brake-blocks gripping the drums on the driving axles, (*b*) an automatic gear which applies a steam brake to two of the drums when the speed of the engine exceeds 5 miles an hour, and (*c*) by the compression of air in the cylinders, air from outside being drawn in through the exhaust ports, compressed, and expelled through a special regulating valve The latter method is generally used and water jets are introduced into the cylinders to cool the air Water is carried in side tanks having a capacity of 440 gal , while the coal bunker holds 10 cwt , the weight of the engine in working order is 17·22 tons, its load of 18·5 tons being conveyed at a speed of 4 to 5 miles an hour

The rack bars are cut to form in one operation in a milling machine by a gang of cutters , they are 70 7 in long, and have 15 teeth of 4 72 in pitch and 1·97 in depth , the thickness is 0 98 in on gradients steeper than 1 in 9 and 0·79 in on flatter gradients The bars are arranged so as to break joint and are bolted at the middle and ends to rolled steel chairs, weighing 12 lbs each, which are bolted to the transverse sleepers The rails are flat-footed and weigh 41·25 lb per yd. , the sleepers are of steel of trough section with turned-down ends, 6 ft long and spaced 35 45 in apart , the rails are fastened by clips and bolts At intervals of 50 to 150 yd , according to the gradient, vertical iron joists, set in concrete blocks, bear against the sleepers and act as stops to prevent the track creeping down hill

An adjacent print shows the complete engine Inv 1904–22 29311

107. MODEL OF PILATUS RACK LOCOMOTIVE (working). (Scale 1 . 16) Made from drawings prepared in the Museum, 1909

The railway up Mount Pilatus, near Lucerne, Switzerland, was constructed in 1886–88 It is 2 83 miles long, and rises 5 370 ft , the average gradient is 1 in 2·50, and the maximum 48 per cent , or 1 in 2 08. The horizontal curves have a radius of 4 chains, and the vertical ones a radius of 25 chains , the gauge of the rails is 31·5 in (800 mm) The gradients being so much steeper than those on previous lines worked by rack locomotives, experiments were first made to test the suitability of the ordinary vertical toothed wheel system, and it was found that the wheels rose out of gear when the load was put on A system was therefore devised by Dr E Locher in which a pair of horizontal toothed wheels gear with a double horizontal rack , this arrangement may be considered as a toothed development of the centre rail system (*see* No 104) In order to reduce weight, the engine and carriage are built on the same underframe The model represents the framework and gearing of one of the locomotives, built at the Swiss Locomotive Works, Winterthur, for use on this line It is shown, with its track, mounted on a gradient of 1 in 2·08.

The underframe is carried on four flangeless wheels, 15 75 in diam , with a wheel-base of 15·92 ft The engine is placed at the lower end and has two horizontal outside cylinders, 8·62 in diam. by 11·75 in stroke, with the valve chests below them The connecting rods drive a horizontal crankshaft, upon the middle of which a spur pinion is fixed, and this, by a spur wheel and two pairs of bevel wheels, drives the vertical shafts that carry at their lower ends the toothed driving wheels The vertical bevel wheels are not rigidly connected with the spur wheel, but have a slight relative motion to give a differential action

when passing round curves. The driving wheels have 15 teeth and a pitch diameter of 16·1 in., they are fitted with guiding rings below, equal in diameter to the pitch circles, and these roll upon the central rail which supports the rack, and also prevent the wheels from rising out of gear. The gear ratio is 3·8 : 1 and the tractive factor is 206; no springs are fitted to the axles. At the front end of the frame is placed another pair of toothed wheels similar to the driving ones, and these are used to guide the car and also to actuate the automatic brake The engine frames are between the wheels and are strongly braced by top and bottom plates; the central portion is used as a water tank. The boiler is of the usual locomotive type, but is placed transversely; it has a heating surface of 215 sq ft and a grate area of 4 sq. ft; the steam pressure is 176 lb. per sq. in.

The normal speed of the engine is 2·25 miles an hour and, on the downward journey, is controlled by three brakes These consist of (*a*) a hand-applied band brake on one of the engine crank discs, (*b*) a cylinder air-brake (*see* No. 106), and (*c*) an automatic brake that acts upon a drum connected with the front pair of toothed wheels by worm gearing, and which comes into action if the speed exceeds 3 miles an hour; the latter brake can also be applied by the front brakesman Clips are fitted, embracing the running rails, to guard against derailment by wind The water tank carries 176 gal, and the coal bunker holds 2·5 cwt. The weight of the loaded car is 10·5 tons

The permanent way consists of flat-footed rails, in lengths of 19·7 ft, bolted to channel iron cross sleepers The rack is formed of steel bars, 9·85 ft. long, with 35 teeth, 3·38 in pitch and 1·1 deep, milled along each side, these are bolted to the top of a continuous saddle-shaped rail, which is itself bolted to chairs formed of channels and angles riveted to the cross sleepers Due allowance is made for expansion In order to prevent the track from slipping down hill, the cross sleepers are bedded on a continuous solid masonry bed, and are secured by sling bolts which pass round it.

An adjacent print shows the complete engine Inv 1909-2 S.M. 218

ELECTRIC LOCOMOTIVES.

108. ELECTRIC LOCOMOTIVE (1890). Presented by the City and South London Railway Co., 1923

This is one of the original locomotives built by Messrs Mather & Platt, Ltd, and Messrs Beyer, Peacock & Co, Ltd, in 1890, for the City and South London Railway which was the first electrically operated railway in Great Britain and the first tube railway in the world The original intention was to work the line on the cable haulage system, but the success of electric traction abroad led to its application on this line instead of the cable

The subway consisted of two cast-iron tubes 10·17 ft diam inside, and electric locomotives were adopted because there was not sufficient room for motors on the carriages themselves The locomotive runs on four wheels 27 in diam with a wheel-base of 6 ft, the frames and bearings being outside the wheels. Each axle is driven by an independent electric motor and the chief feature of the design is that the armatures are built directly on the axles, this arrangement had been suggested by Sir William Siemens but had not previously been put into practice The field magnets embrace the armatures and are supported in part by brackets bearing on the axles and partly by links connecting the yokes to a cross beam of the locomotive frame, thus permitting limited freedom of angular motion of the fields round the axles, compensating for the rise and fall of the axle-boxes in the hornblocks The magnets are of the Edison-Hopkinson form and series wound, while the armatures are of the Gramme ring type, the two motors are connected in series

The electrical conductor is a mild steel channel, weighing 10 lb per yard, placed between the rails and carried on glass insulators fixed to alternate sleepers, it is set 1 in below the level of the running rails and wood ramps are provided at points and crossings to carry the collectors over the rails. Two sliding collectors are provided on the locomotive so that the continuity of the circuit is never broken The current from the conductor is conveyed from the collectors through a fusible cut-out and main switch to a rheostat switch for inserting resistance at starting, and finally through the axle-boxes and wheels to the rails which are used as the return

The trains are fitted with the Westinghouse brake operated by a store of compressed air carried in two reservoirs on the locomotive. At the end of each journey these are charged with air at 80 lb pressure, this charge being sufficient to provide

for about 30 stops. In addition, a powerful hand-screw brake is fitted. The driver's cab occupies the whole length of the engine, the switch gear and resistances being on one side and the brake cylinder on the other. The motors are covered with movable wooden casings and removable windows are provided in the floor over the motor commutators. A speed indicator is fitted which is driven from one axle.

The locomotive measures 14 ft. long, 6·7 ft. wide and 8·5 ft. high; while its total weight is about 12 tons Each motor is rated at 50 h.p. and is capable of giving a tractive effort of 3,000 lb. with a current of 226 amperes 40-ton trains were hauled at an average speed of about 12 miles per hour, the maximum speed varying from 20 to 25 miles per hour. The overall efficiency of the system as between the indicated power of the steam engine and the effective power at the rails was about 60 per cent.

The permanent way consisted of flat-footed rails weighing 60 lb. per yard spiked to transverse sleepers, the ends of which rested directly on the tube lining.

The construction of the line from the Monument to the Elephant and Castle was authorised in 1884 and the extension to Stockwell in 1887; construction was commenced, under Mr. J. H. Greathead, in May, 1886 and the line was formally opened on Nov 4th 1890 Extensions to Clapham Common and Islington were made shortly afterwards and finally to Euston. The small size of the tubes greatly restricted the operation of the line and in 1923 they were enlarged so as to permit the use of motor carriages as used on the other tube railways

Inv. 1923–301

109. MODEL OF AN ELECTRIC LOCOMOTIVE (working) (Scale 1 · 4) Lent by Messrs Beyer, Peacock & Co, 1894

This electric locomotive, patented by Messrs R Peacock and H L Lange in 1890, is designed to receive its current from a contact piece sliding on a central rail, or from an overhead conductor The chief object of the arrangement is to dispense with spur gearing and yet keep the armatures well above the mud and dust, which, owing to the small driving wheels necessary, are found in the neighbourhood of the axles

There are two armatures, and each is connected by two overhanging cranks and diagonal coupling rods with one of the driving axles, so that the axles are driven independently The axle-boxes slide in inclined guides, so that the pull of the coupling rods shall not be felt on the springs. The armatures are in a single magnetic circuit, and the field windings are arranged in one horizontal and two vertical coils below the platform A screw brake is provided for stopping, but the starting levers and resistances are not shown

The model is carried on friction wheels which can be rotated from outside the case, so that the motion of the connecting rods may be followed

Inv 1894–134 *1741

110. STEAM TRAMCAR. (Scale 1 : 8.) Contributed by Mrs. Grantham, 1876.

Mr. J Grantham in 1871 patented a steam car in which the machinery was below the floor and two vertical boilers were on opposite sides of the car, so as to leave a clear passage from end to end. The exhaust steam was condensed in exposed pipes; the boilers were fired by a screw conveyor, and the whole of the machinery and the brakes were controlled from either end of the car by one man.

In 1872 a car on this plan was made, 30 ft. overall and accommodating twenty inside and twenty-four outside passengers. Each of the boilers was 4·33 ft high by 18 in diam. and fitted with Field tubes; the grate area was only 1·2 sq ft., while the pressure was 90 lb The two cylinders were 4 in. diam. by 10 in. stroke and directly drove wheels 30 in diam, so that the tractive factor was 5·33; the axles were 10 ft. centres and the total weight empty 6·5 tons. The car, after being tried successfully on a railway, was placed in 1873 on the tramline between Victoria Station and Vauxhall, but it ultimately failed owing to deficiency in boiler power and to difficulties in firing; it was, however, the first steam tramcar that worked in England.

The model shows additional features patented in 1872; the driving wheels are flangeless and the axles of the other wheels swivel, so as to render the car dirigible for use on common roads, also these wheels are loose on their axles; for use on rails there are two axles with flanged wheels which can be lowered by levers till they bear on the rails. The double gates at either end of the car are for checking the fares.

The Grantham car, after being modified by Mr. E Woods, continued in use on the Wantage tramway till 1881. Inv. 1876–1271.

LOCOMOTIVE DETAILS.

111. MODEL OF COUPLING WHEELS FOR LOCOMOTIVES. (Scale 1 : 8) Contributed by W. B. Adams, Esq, 1869

This method of connecting the wheels of a locomotive, so that the adhesion due to the total weight of the engine shall be available for tractive purposes, was provisionally patented by Mr Adams in 1855, the arrangement had, however, been patented in 1837 by Mr J Melling, so Mr Adams did not proceed with it In recent years the device has been tried on a practical scale in America; it enables wheels of different diameters to be coupled, and also gives a connection that may be temporarily made when required, even while running

The model represents a radiating axle locomotive frame, with eight travelling wheels, of which the front four are frictionally coupled by an elevated pair of wheels pressing upon them, while the hind four wheels are similarly connected by another pair The upper axles may be independently driven, but as here represented the central pairs of travelling wheels are to be connected by coupling rods, one pair only being directly driven Arrangements are made for throwing any required proportion of the weight of the engine upon the elevated axles In Melling's specification steam-moved levers were introduced for this purpose

Inv 1869–52

112. MODEL OF LOCOMOTIVE FRAME WITH RADIATING AXLES. (Scale 1 . 4) Contributed by W. B Adams, Esq., 1869

This represents the underframe of a four-coupled tank engine having the leading and trailing axles fitted with the radiating arrangement patented by Mr Adams in 1861, by which, when a curve is entered, the axle-boxes, while sliding endways between the hornblocks, move the axles into a position that is approximately radial to the curve This result is obtained by shaping the boxes and hornblocks to arcs of a circle, as, however, an inventor had in 1857 proposed a similar arrangement, but with the boxes held in straight guides, Mr Adams prepared the two models in front of the case to show that the earlier scheme was unworkable The engine represented would have a wheel-base of 22 ft, and it was claimed that it would pass round a curve of 99 ft radius

The springs of the boxes of the driving wheels in the model are connected by equalising levers, by which the heavy load upon them is equally distributed between the two wheels on each side, irrespective of the inequalities on the rails

Inv 1869–51

113. MODEL OF DRIVING ARRANGEMENT FOR ELECTRIC LOCOMOTIVE. (Scale 1 16) Presented by Messrs Brown Boveri & Co., Ltd., 1923.

This demonstration model shows the method of connecting the armature shaft and the driving wheels of an electrically driven locomotive with individual axle drive It was patented by the donors in 1916 and 1917, and is being used on locomotives built for the Swiss Federal Railways.

It is essentially an arrangement for coupling two shafts, normally concentric but which may have a small amount of eccentricity or lack of parallelism such as that due to the motion of a locomotive on its springs. The motor is mounted between the locomotive frames, immediately above the driving wheels, and with its shaft projecting at one side. This shaft carries a spur pinion which is mounted on a spherical seating and provided with springs for taking up the tangential forces Gearing with the pinion is a large spur wheel mounted on a hanging bracket outside the frame and concentric with the driving wheel Two crank pins with spherical ends project from the driving wheel and pass through holes in

the web of the spur wheel. These pins are connected by short links with spherical pins on the ends of rocking levers pivoted on the spur wheel and having their opposite ends geared together by toothed sectors. These links and levers transmit the driving force but permit the spur wheel to move relatively to the driving wheel as the locomotive rises and falls or rocks on its springs.

The individual drive does away with jack shafts and coupling rods with their inertia stresses and necessity for frequent adjustment, while it permits the whole weight of motors and gearing to be sprung As actually made the motor shaft has an outside bearing and the gears run in an oil bath which requires no attention.

In the model the base represents the locomotive frame Inv 1923–399.

114. MODEL OF CYLINDERS AND SMOKE-BOX OF COMPOUND LOCOMOTIVE. (Scale 1 : 4) Presented by H. and R. W. Worsdell, Esqs, 1922.

This shows an arrangement of valves by means of which the power of a two-cylinder compound locomotive is increased, when starting, by admitting high-pressure steam directly to the low-pressure cylinder. It was patented by Mr. T. W. Worsdell in 1885 and 1892

A chamber is provided in the high-pressure exhaust-pipe and in this is mounted a square flap-valve attached to a spindle passing through the side of the smoke box At the back of this chamber, below the flap-valve, is an inlet pipe by which the high-pressure steam is admitted

Outside the smoke-box is fitted a horizontal cylinder containing a plunger, the rod of which is connected with a lever on the spindle of the flap-valve The cylinder also forms a connection between the steam supply pipe and the inlet to the high-pressure exhaust pipe A hand operated valve admits steam which pushes out the plunger and closes the flap-valve, thus preventing high-pressure steam from causing a back pressure in the high-pressure cylinder When the plunger has moved out it opens the steam passage to the low-pressure valve chest, so permitting the engine to start with both cylinders in action When the engine has started, the steam valve is closed, and the exhaust from the high-pressure cylinder then pushes open the flap-valve and passes to the low-pressure chest

The model represents part of a goods engine similar to that shown in No 85, the cylinders being 18 in and 26 in diam Inv 1922–538.

115. MODEL OF ADAMS'S LOCOMOTIVE BLAST PIPE (Scale 1 4) Lent by W Adams, Esq, 1890

By this arrangement the exhaust steam is discharged as a hollow cylindrical jet, thereby greatly increasing the amount of surface presented to the gases in the smoke-box, so that a greater exhaustive effect is produced The gases carried into the chimney by the external surface of the jet are gathered from the upper portion of the smoke-box, as with the common form of nozzle, but the inner surface acts only on the gas drawn from the lower portion of the box and so increases the draught through the lower tubes of the boiler, which otherwise are not so active as the higher ones Inv 1890–58 20,640

116. PISTON ROD PACKING FOR LOCOMOTIVES. Lent by the United States Metallic Packing Co, Ltd, 1921.

This is a sectioned example of the metallic packing patented by Messrs W E. Plummer and W M Kermode in 1893 It permits of free lateral and angular motion of the rod, is self-adjusting under wear, and its contact round the rod is chiefly derived from the steam pressure.

The packing consists of three babbit metal rings contained in a conical cup fitted with a gland which is forced home by a helical spring assisted by the steam pressure. The front of the cup is free to slide on the plane face of a washer, the other face of which is spherical and beds in a similar recess on the stuffing box cover, while the gland end is free to slide on the plane face of a bush on which the spring acts The cover is bolted fast to the stuffing box and the chief closing pressure upon the gland and packing is that exerted by the steam With the exception of the soft metal rings, the whole of these parts are bored much larger than the piston rod diameter

The arrangement will work for a long time without attention while keeping perfectly steam tight; wear is diminished owing to the pressure being relieved during exhaust strokes. Inv. 1921–30.

117. MODEL OF BUILT-UP CRANK AXLE. (Scale 1 : 4.) Made from information supplied by H. A. Ivatt, Esq., 1909.

This model represents a locomotive crank axle built up in the manner patented by Mr. Ivatt in 1908; by this construction flexibility is secured, the axle is balanced and renewal of parts is facilitated.

The axle has two cranks at right angles to one another and is built up of four pieces The two outer pieces consist of a wheel seat and journal together with the outer crank web and crankpin. The inner pieces consist of a web which is extended backward at an angle of 45 deg., bent and thickened, so that the extensions of the two cranks meet and are bolted together with a tongue and groove joint, these form the balance weight The inner ends of the crankpins are shrunk and keyed into holes in the webs, and the outer webs are hooped

An adjacent print shows another form of this axle, in which the two central crank webs are replaced by a straight piece of shaft with end palms that are bolted to extensions of the inner crank wel so that eccentrics may be fitted

Inv 1909-78 S M 1355.

118. LOCOMOTIVE PISTON VALVE. Lent by the Chief Mechanical Engineer, Great Central Railway, 1921.

This shows a 10 in piston valve of the form patented by Mr J G Robinson in 1911 and 1914 It is designed for inside steam admission, and is fitted with special ring valves to release any undue pressure in the cylinders, and also to allow the passage of air from one side of the piston to the other when coasting with the steam shut off

Each piston of the valve is composed of two discs fixed to the spindle and between which the packing rings are fitted The rings are in three parts, an inner solid ring, a wide split ring surrounding this, and a narrow split ring placed on the exhaust side of the wide one The broad ring has two circumferential grooves on it, and both it and the solid ring have radial holes drilled through them, so that the interior of the piston may communicate with the cylinder ports The inner disc of each piston has a circular row of holes through it which are normally covered by an annular flat-faced valve on its outer surface, these valves are normally held closed by the steam pressure, but allow a free passage between the cylinder ports and the steam chest, should the pressure in the cylinder become too high, or should a vacuum be formed in the steam chest as when running with steam shut off Stops are provided to limit the lift of the annular valves A sectional drawing is also shown Inv 1921-538 and 539

119. ORIGINAL MODEL OF LINK MOTION REVERSING GEAR. Lent by William Howe, Esq, 1893 Plate VIII, No. 1.

This is the original wooden model made by William Howe, of the Forth Street Works, Newcastle, in 1842, to illustrate his invention of the link motion It was submitted to Robert Stephenson, who at once tried it on a locomotive then being built for the North Midland Railway Co (*see* No 21) Since that time it has remained the most popular form of reversing gear owing to its simplicity and the ease with which it permits the point of cut-off of the steam to be varied, so reducing the consumption by allowing the steam to work expansively It seems probable, however, that this device was originally designed to be a reversing gear only, its use in varying expansion not being discovered until later. The construction is described in connection with the larger model No 120

Inv 1893-177 19,379

120. MODEL OF HOWE'S LINK MOTION APPLIED TO A LOCOMOTIVE. (Scale 1 : 2). Lent by T. Jeffrey, Esq., 1870.

This is a working model of what is usually known as Stephenson's link motion, as arranged for reversing and expansion gear of locomotive engines, it shows a section through the cylinder, piston, slide valve, and ports, so that its effect upon the working of the valve can be observed There are two eccentrics on the axle, one set in the correct angular position for going forward, and the other for going backward, and these are connected by rods, one to each end of a curved link, in which slides a block attached to the valve rod The link can be raised or lowered by the reversing lever and thereby bring either end of it to act upon the valve rod, so that the valve receives motion from one eccentric or the other. By

fixing the lever at intermediate positions, however, the valve is caused to receive a combined motion from the two eccentrics, equivalent to that from a single eccentric having a shorter travel and a greater advance, the effect of which is to cause an earlier cut-off in the cylinder. Inv. 1870–5. 19,257.

121. MODEL OF GOOCH'S LINK MOTION (working). (Scale 1 : 4) Made in the Museum, 1900.

This gear, known as the stationary link motion, was invented in 1843 by Mr afterwards Sir Daniel Gooch, Bart, and employed by him on the Great Western Railway The actual arrangement represented was that on a locomotive built in 1847, and the model shows a horizontal section through one of the cylinders, with its piston, slide valve, etc, together with the crank and eccentrics. With this gear, constant lead is secured for all degrees of cut-off owing to the link being curved to a radius equal to the length of the rod connecting the block with the end of the valve rod, this radius rod, however, makes the overall length of the gear greater than that with the shifting link The link itself is suspended from a fixed point, and swings nearly horizontally, the point of attachment usually being at the centre of the link in engines that frequently run reversed The eccentric rods are attached one to each end of the link, and the linking up is effected by altering the position of the block in the link by the usual reversing lever Inv 1900–34 29,808

122. MODEL OF WALSCHAERTS VALVE GEAR (working) (Scale 1 : 4) Made in the Museum, 1901 Plate VIII, No 2

In this valve gear the motion for the valve is derived from that of a point describing a circular path round the crankshaft combined with that from another point receiving a reduced reciprocating movement from the piston, the former component, which by a curved link can be varied and reversed, enables the grade of expansion to be altered or the engine to be reversed, the other component gives the lead, which is constant for all grades, the distribution being, therefore, rather better than that obtained with link motions

The original form of this gear was introduced in 1844 by Mons E Walschaerts, of the Belgian State Railways, but it had an unnecessarily complicated arrangement of the link, he had corrected this before 1848 and so brought the gear to its present form except that he still used one eccentric

Although from its introduction this gear was occasionally used and was generally known to give an excellent steam distribution, it made but little progress till after 1859, when, on some outside cylinder Crampton engines, built for the Northern Railway of France and fitted with it, the single eccentric hitherto retained was displaced by a light return crank, as shown in the model, thus avoiding the use of eccentrics As thus simplified, the motion has been generally adopted in Belgium since 1860, and in Germany since 1875, nearly all modern Continental and many British locomotives now have their valves actuated in this manner

The model shows the gear as arranged on an engine, built about 1883 for a French railway, the cylinders are 17·3 in diam. by 25·6 in stroke and drive four coupled wheels 79·5 in diam. The slide valves are of the piston type, placed above the cylinders, which, as in most Continental locomotives, are outside the frames Each valve is driven by a lever, the bottom end of which is connected with the crosshead and an intermediate point close to the top end with the valve spindle The top end is connected with a radius rod, whose other end fits in a curved link, within which its position is adjustable by the reversing lever This link is rocked by a pin on a return crank from the main crank pin and 90 deg behind it By this arrangement the motion of the valve spindle is compounded of two motions, one derived from the crosshead, giving the lead, and the other from the link rocked by the eccentric pin, giving a motion corresponding to that from an eccentric 90 deg in advance of the crank pin, but this motion is capable of reduction and reversal by moving the end of the radius rod in the rocking link. The details of the gear represented are .—travel, 5·05 in.; outside lap 1·18 in., lead, 0·2 in.; and maximum opening to steam, 1·34 in.

This valve motion is shown on the Fairlie locomotive (*see* No 73), on the four-cylinder compound locomotive (*see* No. 95), and also on the compound marine engines of the P S. "Princesse Henriette" (*see* Marine Engineering Section).

An interesting modification of this gear was devised in 1868 by Prof. A Stévart for application to an engine with two cylinders placed either in planes at right angles working the same crank, or in the same plane on cranks at right angles; from the crosshead of one cylinder is obtained that part of the motion for the valve of the other usually derived from an eccentric, the complete motion for the two valves being thus obtained entirely from the two crossheads Successful modifications have also been introduced by Messrs Kitson, of Leeds, and other engineers. Inv. 1901–21. 29,804

123. MODEL OF ALLAN'S STRAIGHT LINK MOTION. (Scale 1 : 2) Presented by A. Allan, Esq, 1862.

This is a working model of the link motion, patented by Mr Allan in 1855, for the valve gear of locomotives. One eccentric is set in the correct angular position for forward motion, and the other for backward motion of the engine The reversing lever shifts both the link and the block at the same time, instead of shifting the link only, or the block only, as in former link motions By this arrangement the link can be made straight, also the vertical height required by the gear is reduced Inv 1862–28 19,253

124. MODEL OF REVERSING GEAR (Scale 1 : 10.) Woodcroft Bequest, 1903

This is a model of the driving gear of an inside cylinder locomotive, fitted with a reversing arrangement patented by Messrs A Ogilvie and J Richardson in 1858

The slide valve of each cylinder is driven by a single eccentric, and the reversing is performed by a slide valve, moved by a lever from the footplate, and situated in the main steam pipe Steam and exhaust pipes proceed from the valve chest of each cylinder, and by the hand-moved valve these steam and exhaust passages are interchanged

This gear does not permit of expansive working, and is inferior to the link motion, but for certain purposes is more convenient, *e g*, some steam steering gears reverse in this manner Inv 1876–1270

125. MOTION DIAGRAM OF LOCOMOTIVE VALVE GEAR WITH "CORLISS" VALVES (Scale 1 5) Constructed by Mons P Regnard, 1899

This shows a valve gear patented in 1890 by MM Durant and Lencauchez, and considerably used on the Paris and Orleans Railway for both express and goods engines

Each of the cylinders has two semi-rotating steam valves at the top, and two similar exhaust valves below Such cylinders have been fitted to existing engines, the original valve motions, which were of the Gooch type, being retained The two steam valves are worked by a rod from the block in the usual way, while the exhaust valves are driven from another point in the block through an intermediate lever, linking up and reversal are performed by moving the block in the ordinary manner

The large port areas, reduced clearance, and diminished "wall" surface secured by this arrangement were stated in 1893 to have shown a reduction of 15 per cent in the steam consumption, when compared with that of similar engines with ordinary slide valves, and that the wear of the valve gear was still more materially reduced Inv 1899–1

126. DRAWING OF VALVE GEAR FOR THREE CYLINDER LOCOMOTIVE. (Scale 1 : 8) Lent by the Great Northern Railway Co.

This shows a valve gear in which the motion of the inside valve is obtained by combining the movements of the two outside valves by means of a system of levers patented by Mr. H N. Gresley in 1915

In this arrangement a two-to-one rocking lever is pivoted to the frame in front of the cylinders, its longer arm being attached by a short connecting rod to one of the outside piston valve tail rods, while its shorter arm carries an equal-armed floating lever, the extremities of which are united by short links with the other two piston valve tail rods As the outside engine cranks are set at 120 deg. to each other, this arrangement gives a motion to the inside valve approximately equivalent to that required by a third crank set at 120 deg. to the other two.

In the drawing it will be noticed that the outside crank is set at 114 deg and 126 deg with the outside cranks respectively, this being done to allow for the greater inclination of the axis of the inside cylinder The outside valves are driven by Walschaërts valve gear, Skefko ball bearings being fitted to the return cranks, and Hoffmann roller bearings to the lever pivots of the inside valve gear
Inv. 1921–677.

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127. "MENNO" COMPRESSED AIR GREASE CUP. Presented by Messrs. Lubricators, Ltd., 1919

This lubricator was patented by Mr J F Lewis of Philadelphia, in 1905. In it the grease contained in the cup is fed to the bearing in a constant stream by air compressed in an inverted cup-shaped cap which screws into the body of the lubricator.

The cap or air container has a flat disc which fits loosely within it and which, whilst being free to move vertically, is made to rotate with the cap by means of a flat link sliding in a central guide tube As the cap is screwed into the body the disc flattens the grease and prevents the air from forcing a passage through it The grease itself acts as a seal and prevents leakage at the screwed joint A funnel in the cup helps to secure an even flow, and is pierced by small holes through which grease escapes when the disc rests on the top of the funnel Should the adjustment of the cap be neglected the journal will communicate its rise in temperature to the air, which will expand and increase the supply of lubricant

The example shown is of 3 oz capacity and is for use on locomotives, it is machined from a steel bar
Inv 1919-341 S M 1223

128. MECHANICAL LUBRICATOR. Presented by Messrs C C Wakefield & Co, Ltd, 1919

This is a sectioned example of the multiple pump lubricator patented by Sir Charles C Wakefield in 1913 for use on locomotives It delivers oil under pressure to six different points simultaneously, the amount discharged to each point being capable of independent adjustment

The six single-acting pumps are arranged vertically in two rows within the oil container and each consists of a cylindrical sliding sleeve fitting over a hollow plunger fixed to the bottom of the container The sleeves are raised and lowered by flanges on a crosshead, which is guided vertically by a downward extension sliding in a cylinder bored in the base of the lubricator, and is reciprocated by an eccentric on a shaft passing through a slot in the crosshead The lower flange on the crosshead lifts the sleeves by means of collars formed on them, while the upper flange depresses the sleeves by screwed tappets projecting downward so as to bear on their closed upper ends The pump barrels are provided with a row of oil ports drilled through them, which are uncovered when the sleeves are in their highest position, but are closed when the sleeves begin to descend When the tappets are screwed right down the sleeves move in unison with the crosshead and have a maximum stroke If, however, a tappet is unscrewed somewhat, the sleeve will be lifted by the lower flange as before, but a portion of the down stroke will be lost before the tappet reaches the sleeve and the pump stroke will be shortened by that amount, so that a smaller amount of oil will be discharged into the delivery pipe which is connected to the lower end of the pump where a non-return valve is fitted

The driving shaft is rotated slowly by a ratchet wheel and a lever connected with some reciprocating part of the engine so that the oil supply is proportional to the speed A reversed ratchet wheel is provided inside the oil container to hold the pumps during the return strokes of the ratchet lever The container holds 1 gallon of oil and is filled through a hinged lid beneath which a strainer is fitted
Inv 1919-419 S M 1189

129. STEAM SANDING APPARATUS FOR LOCOMOTIVES. Lent by Messrs. Gresham & Craven, Ltd., 1921.

This is a sectioned example of a rail sanding apparatus in which a steam ejector is used to force sand beneath the driving wheels of a locomotive, so as to increase the adhesion when the rails are greasy. It was patented by Mr J Gresham in 1887 and 1909

The sand, which must be dry, is contained in a box with sloping sides so that it can fall easily into a sand trap, which is essentially an upward bend in the pipe,

where it is normally stopped. When steam is turned on, it forms a jet within the sanding pipe, causing a partial vacuum which draws air through an opening above the trap at such a velocity that it stirs up the sand and carries it through the sanding pipe to the rails

The steam control handle is fixed to the spindle of a sliding disc valve, which, when moved to the " on " position opens a port to the ejector, and in the " off " position opens a passage to the drip pipe On the valve spindle is a cam which in the " on " position of the handle raises a mushroom valve and admits steam to the chamber containing the disc valve. This arrangement prevents any steam leaking into the ejector, and perhaps wetting the sand, when the apparatus is not in use

Inv. 1921–592

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130. " SERVE " BOILER TUBES. Presented by Messrs. John Brown & Co , Ltd , 1904.

These boiler tubes, patented in 1885 by Mons. J. P Serve, are provided with internal longitudinal ribs, or fins, which increase the surface for the absorption of heat from the furnace gases, while the external cylindrical surface of the tube suffices for the transmission of this heat to the water , the ribs also increase the rigidity of the tubes Some experiments, with plain tubes and ribbed ones of the same diameter and length, gave an increase of 15 per cent in the amount of water evaporated per lb. of coal in favour of the ribbed tubes , for locomotive boilers, in which they are extensively used in France, the small plain tubes have been replaced by about one half the number of " Serve " tubes of larger diameter, and it is stated that by their use a boiler may have its tubes considerably shortened, thus reducing weight, without diminishing its power or efficiency It was also found that 1·2 sq ft of inner surface of ribbed tube were equivalent to 1 sq. ft of inner surface of smaller plain tube, and that by the use of ribbed tubes the requisite surface could be provided in a locomotive boiler with fewer holes in the tube plates than would otherwise be necessary

The specimens show different stages in the process of manufacture, which consists in preparing, by rolling, a flat plate of the required width and thickness, but having the necessary ribs projecting from its surface , this plate is then bent to cylindrical shape and a lap-welded joint formed, either by passing the tube, on a suitable mandrel, between welding rolls or under a power hammer At each end of the tubes the ribs are cut away for some inches to allow of their being expanded into the tube plates in the usual manner

The tubes are made of mild steel, and in sizes ranging, for land boilers, from 2·5 in to 3 in external diam , those for locomotives being usually 2 75 in diam , those shown are 2·5 in diam , 0 125 in thick, and have seven ribs projecting 0 5 in.

Inv 1904-111.

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131. MODEL OF SCHMIDT LOCOMOTIVE SUPERHEATER (Scale 1 : 4) Made in the Museum from information supplied by Marine & Locomotive Superheaters, Ltd , 1921

This represents the form of fire tube superheater for locomotives patented by Dr W Schmidt in 1900 and 1905, with improvements patented by Mr J H. Stirling and the makers, in 1912 and 1913 In its original form it was first used in 1901 on the Belgian State Railways and is now very extensively employed in Great Britain and abroad The superheater is designed to give a high degree of superheat, the final temperature of the steam being about 640° F , with a resulting economy in fuel of 25 per cent , and in water of 35 per cent The use of steam at this high temperature supersedes compounding, but it necessitates specially constructed piston valves and stuffing boxes

In the upper part of the boiler the usual fire tubes are replaced by three rows of tubes of large diameter In each tube is inserted a superheater element or section consisting of a continuous double-looped tube of seamless steel, the ends near the fire box being welded together The open ends of each element extend into the smoke-box, where they are bent upward and fitted with collars, which are drawn up to the header in pairs by a bridge bar and single bolt, grooved copper washers being inserted to form the joint In the construction of header shown the passages for saturated and superheated steam are formed one above the other in a steel casting extending across the upper part of the smoke-box

The chambers to which the superheater elements are attached extend longitudinally and open alternately into the saturated and superheated steam passages. By attaching the separate ends of the elements to adjacent chambers the steam coming from the regulator is constrained to pass from the saturated steam passage

to one end [illegible]h element and thus simultaneously through all the elements, to be collected [illegible]e passage for superheated steam and distributed to the cylinders.

The p[illegible] of the superheater in no way interferes with the cleaning of the boiler tu[illegible]d any or all of the elements may be easily removed for inspection without [illegible] a single nut from its bolt, as the latter are accommodated in open-ended [illegible] between the steam chambers. When fitted in a boiler the smoke-box end of the superheater is enclosed in a damper-box so that regulation can be effected.

Inv. 1921–541. S M. 1,424 & 5.

132. MODEL OF SUPERHEATER HEADER. (Scale 1 : 2) Presented by Messrs Marine & Locomotive Superheaters, Ltd., 1920.

This represents a locomotive superheater header designed to secure greater tightness of the element joints; this is attained by the use of inclined joint faces and wedge-headed bolts The model shows the sectioned half of an 18 element header.

The header is an iron casting placed across the upper part of the smoke-box and attached to the tube plate by a central flange through which the wet steam enters. The back part of the casting is divided by a vertical partition into two parallel passages, the back one of which contains the wet steam and the front one the superheated steam From the lower portion of the header project seven horizontal chambers communicating alternately with the wet and superheated steam passages The sides of each pair of chambers are inclined at 60 deg to one another, and each inclined face has three recessed holes for the reception of the element tube ends The tube ends are bent normal to the faces and have steel collars welded to them Slotted wedge-headed steel bolts embrace the two adjacent tube ends, and, by means of the collars, pull them up against the faces, copper joint washers being inserted under the collars The bolts are accommodated in slots between the chambers and are fitted with gunmetal cap nuts and steel washers With this arrangement the joint pressure will be twice the load on the bolt

Inv 1920–123

133. MACHINE FORGED ELEMENT ENDS FOR LOCOMOTIVE SUPERHEATERS Presented by Messrs. Marine & Locomotive Superheaters, Ltd, 1922

These examples illustrate the method of manufacture of the return bends for superheater tubes The bends are forged from the tubes themselves, by special machines, in the manner patented by Messrs C. H True, N T. McKee and C. H W Brandt between 1915 and 1920 It is claimed that this method produces perfectly smooth ends of standard size and thickness, more perfectly welded than by other means, and offering the least possible resistance to the flow of hot gases through the flue tubes.

The two element tubes which are to be joined are clamped together at the correct distance apart, brought to a welding heat, and placed in a forging machine which splits the ends where they lie close together, opens them out, and welds the opened parts together as shown by example 1 The end is then reheated and closed in a rotary swaging machine, by split dies, whereby the end is shaped as in example 2 The final press operation removes the excess metal at the tip, flattens the sides and finishes the bend as shown by example 3 Example 4 is a finished bend sectioned to show the interior and the thickened end which resists the destructive effect of the high temperature flue gases

The tubes are 1 375 in. external diam. and 0·156 in. thick. They are tested, when finished, by hydraulic pressure at 1,000 lb per sq in. Inv 1922–644.

134. ELEMENT JOINTS FOR LOCOMOTIVE SUPERHEATERS. Presented by Messrs. Marine & Locomotive Superheaters, Ltd., 1922.

These are examples of the form of joint for superheater elements patented by Messrs. F. J. Cole and S. Hoffmann in 1911. It supersedes the flat copper washer joint previously used, (*see* No. 131), as it makes a more satisfactory joint, is easily dismantled and is perfectly tight when replaced.

The ends of the tube are enlarged and the outer edge and back of the enlargement form parts of a spherical surface. The end of the seats on a 45 deg. bevelled recess round the hole in the header and each pair of ends is held up by a tee-headed bolt and a bridge bar furnished with washers which bear against the back edges of the enlarged tube ends. In order to allow flexibility is secured by fitting the Tee-bolt with a spherical washer seated on a conical recess at the back of the bridge bar. The washers and bridge bar are threaded on the tubes before the ends are enlarged and the spherical surfaces on the tube ends are ground true.

Long and short types of the joint are shown Inv 1922–642.

135. DAMPER MOTOR FOR SUPERHEATER LOCOMOTIVES. Presented by Messrs. Marine & Locomotive Superheaters, Ltd., 1922.

This is a form of steam motor for closing the damper of the superheater flue tubes so as to prevent the element tubes from becoming overheated when the engine is shut off

It consists of a single acting cylinder the piston rod of which comes into contact with a lever on the end of a shaft connected with the damper Steam is automatically admitted to the cylinder when the engine regulator is shut so closing the damper and stopping the flow of hot gases through the superheater tubes When the regulator is reopened, the steam is cut off from the damper cylinder, and the damper opens by its own weight or by the action of a counter weight Inv. 1922–645

136. LOCOMOTIVE SUPERHEATER HEADER. Lent by the Chief Mechanical Engineer, Great Central Railway, 1921

This is a sectioned example of a superheater header specially designed so that the elements may be easily removed or replaced It was patented by Mr J G. Robinson in 1911

The header is divided into a series of compartments by vertical transverse partitions Alternate compartments are connected together, the inlet compartments, painted blue, by a longitudinal passage at the back, and the outlet compartments, painted red, by a passage along the top of the header These passages are strengthened by internal longitudinal webs The ends of the tubular elements are expanded into holes drilled in the bottoms of the compartments The front of the header is provided with three easily detachable covers secured by studs and cap-nuts By removing the covers, the tube ends and compartments can be inspected, and, when necessary, the elements can be replaced by the aid of a few simple tools

The example shown is for a two-cylinder engine having 24 superheater elements the tubes of which are 1,375 in outside diameter Inv 1921–536

137. SUPERHEATER ELEMENT ENDS Lent by the Chief Mechanical Engineer, Great Central Railway, 1921

These examples illustrate the method of manufacture of the element ends, or return bends, used in the Robinson superheater

The ends are solid steel forgings which are drilled out in two settings The ends are of slightly smaller internal diameter than the outside of the superheater tubes, so that they may be shrunk on to the tubes, the junction between the tubes and forging is then welded up This method ensures a predetermined thickness of homogeneous metal at the bend, and results in a strong and reliable joint

The examples shown are—the solid forged end, the drilled forging, the forging with tubes secured, and two sectioned ends with tubes Inv 1921–536

138. MODEL OF " PHŒNIX " SMOKE-BOX SUPERHEATER. (Scale 1 : 4) Received 1911

This represents the form of waste gas superheater, for boilers of the locomotive type, patented by Mr. S. S. Macaskie in 1909, and used on several railways It gives a moderate degree of superheat, the steam temperature being raised from 371 deg F at 160 lb. pressure to about 500 F, which is sufficient to obviate cylinder condensation, and to show a reduction in coal consumption of 20 to 25 per cent or even more. The superheater can be fitted to any existing boiler without alteration, except to the smoke-box itself, and ordinary slide valves can be retained.

The superheater consists of two boxes or headers fixed in the lower part of the smoke-box, one on each side, parallel to the axis of the boiler. Each box is divided by longitudinal and transverse partitions forming distinct chambers, and each chamber is provided with a group of superheater tubes, passing from one box to the other round the smoke-box, their ends being expanded into the tops of the headers. The tubes at the rear end pass directly from one header to the other, while the front ones pass into a divided intermediate chamber which has a central conical passage, below the chimney and above the blast pipe, to allow the exhaust steam to pass The steam enters at the outer front corner of one header, takes a circuitous path from the coolest to the hotest part of the smoke-box, and leaves at the inner back corner of the other header. A baffle is fitted behind the exhaust pipe which, in conjunction with the cone over the blast nozzle, causes a good distribution of the hot gases around the superheater tubes before they pass to the chimney The tubes are of small diameter giving a large heating surface Doors are provided on the bottoms of the headers, and the top chamber has sloping joint faces to facilitate its removal The upper part of the smoke-box is made detachable so that the whole superheater may be lifted out easily.

Inv 1911–62. S.M 275

139. LIQUID FUEL BURNER. Made by the Great Eastern Railway Co., 1903

Oil as a fuel for steam generators possesses several advantages, the most important of which are that it requires no stoking, is easily conveyed to the furnace, has a high calorific value, and gives a flame that can be immediately and completely adjusted to the demand for steam, it forms no ash, moreover, and consequently exerts no abrasive action upon the fire-box and tubes These advantages were early recognised, and numerous extensive experiments were carried out at various times in 1834 by Mr J Bourne, in the sixties by Messrs Richardson, Aydon and others, and by Messrs Sims & Barff, who tried oil fuel on a steam yacht, but it was in Russia, about 1874, that oil fuel first came into extensive use by being successfully applied to locomotives and steamships

Several methods of burning oil as fuel have been tried, such as mechanical spraying, air or steam jet spraying, and pre-vaporising, but that introduced in 1865 by Mr Aydon, in which the oil is sprayed into the fire-box by a steam jet drawing in air at the same time, is now most generally used, although for marine work it has the disadvantage of carrying off some of the feed-water

A conspicuous application in this country of oil for steam raising is that perfected on the Great Eastern Railway by Mr James Holden, who commenced experimenting in 1886 In his arrangement the oil is sprayed into the fire-box by a pair of steam jets, hot or cold air being drawn in through the apparatus at the same time, and additional air introduced by means of a ring steam blower, which also completes the pulverisation of the oil drops The spray is burnt in the fire-box over a bed of broken fire-brick, but an extra brick wall is added where the flame impinges, to prevent undue local heating

The burners shown, one of which is in section, are one form of the arrangement patented by Mr Holden in 1886–99, for use on a locomotive provided with the vacuum brake Each burner consists of an outer casing containing three concentric cones forming the nozzles through which pass the air, steam, and oil that form the inflammable spray which is directed into the fire-box As the amount of air thus introduced is insufficient, the spray nozzle is surrounded by a ring of steam jets forming a blower which carries in additional air through the two circular orifices into the fire-box, by which the spray is admitted The central air inlet of these burners is connected with the train pipe, so that the exhaustive action is utilised in maintaining the vacuum, a ball valve preventing the inrush of air when the apparatus is stopped If the brake service is of the pressure type this economy is not practicable, but a heated air supply is provided by drawing the air through a coil placed in the smoke-box In order to increase the quantity of oil that can be effectually sprayed by the two burners, an auxiliary oil supply is led to the end of the spray nozzles, so that oil from it is carried into the furnace with the mixed jet, the supply of oil to the whole of the jet is, however, regulated by a single combined plug and lift valve

It is estimated that 1 lb of oil is practically equivalent in evaporating power to from 1·5 to 2 lb. of coal, and that the most economical oil is the petroleum refuse "astatki," or else coal or oil-gas tar Similar oil-burning arrangements are used for melting metal in crucible furnaces or on an open hearth.

Inv. 1903-50. 26.270.

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140. OIL FUEL BURNER. Lent by the Midland Railway Co., 1921.

This represents the form of oil fuel burner used since 1912 for some locomotives on the Midland Railway.

The oil issues from the top portion of the burner in a thin stream or ribbon and is atomised by falling on to a flat jet of steam which issues immediately under it from a very narrow orifice somewhat wider than that through which the oil flows. The burner is inserted in the lower part of the fire-hole and the oil is fed to it by gravity from two tanks placed on the tender, each of which holds from 400 to 500 gal. The flame is directed under the brick arch and impinges on a fire-brick wall covering the lower part of the tube plate; the fire-bars are covered with a layer of broken fire-brick. The fire is started with wood, and any coal fuel required can be fed through the upper part of the fire-hole The burner can be started when the steam pressure reaches about 40 lb. per sq. in. An adjacent drawing shows the burner fitted to a boiler. Inv. 1921-396 & 446.

141. "UNOLCO" OIL BURNERS. Lent by the United Oil & Coal Corporation Ltd., 1922.

These are two liquid fuel burners of the steam injector type for locomotives.

In the single jet burner the main steam supply enters through an axial nozzle around which the oil fuel enters by a concentric steel nozzle At the front end of the oil nozzle a secondary annular steam jet completes the vapourisation of the oil and spreads it horizontally by means of a specially shaped steel nose-piece fixed to the front of the burner. The body of the burner and the central steam nozzle are of gunmetal.

The triple burner has three similar jets arranged side by side in one casting and, by means of valves, either one, two or three of the jets may be employed as desired The two side flanges, by which the burner is supported, have slotted bolt holes so that the inclination of the burner can be adjusted This burner has also been used by Mr J G Robinson for burning mixtures of liquid fuel and pulverised low-grade solid fuel Inv. 1922-490 & 491.

142. MUFFLED POP SAFETY VALVE. Presented by the Crosby Steam Gauge & Valve Co, 1913.

This is a locomotive safety valve of the type patented by Mr G. H Crosby between 1875 and 1905 It is so designed that it opens suddenly to its full extent when the boiler pressure exceeds the working pressure, thus giving the freest possible discharge, while it closes down again with a reduction of pressure of about 3 per cent. The valve is fitted with a muffler to quieten the discharge, which it does without causing any back pressure The name of the valve is derived from the popping sound made by the suddenly released steam

The valve itself is a spherically edged thick flat disc having two annular flat valve faces; this is held down by a helical spring on two similar seats formed on the valve body When the valve is closed the steam pressure acts only upon the annulus between the two seats, but when the valve begins to open the escaping steam flows outwards over the larger seat direct to the atmosphere, and over the inner seat to a central well which communicates with the atmosphere through four small passages formed in the body The spring is strong enough to hold the valve down against the normal pressure on the annulus, but when slightly opened, the extra pressure, due to the reaction of the escaping steam on the additional central area of the valve, compresses the spring further and causes the valve to open fully and to remain open until the pressure has fallen sufficiently. The use of flat seats gives the maximum opening for a given lift The valve is guided vertically by fitting it within a cylindrical casing that encloses the spring The muffler consists of a narrow annular cylindrical chamber, the inside of which communicates with the main valve outlet, while its walls are perforated for the escape of the steam. The whole valve is surrounded by a casing, having slits at the top, which is screwed on to the body and is adjustable vertically so as to vary the size of the steam passages from the central well and so regulate the action of the valve The pressure at which the valve opens can be altered by means of a screwed spindle at the top of the casing, which presses on the top of the spring.

The valve shown is 3 in diam. and, with a lift of 0·08 in., is capable of discharging at the rate of 9,872 lb. of steam per hour at a pressure of 200 lb. per sq. in.
Inv. 1912-88. S.M, 542.

143. LOCOMOTIVE REGULATOR. Made by Messrs. Sharp Stewart & Co., 1888.

This form of regulator valve was introduced about 1860 and has been largely used. In it a small auxiliary valve opens first thus putting the main valve in equilibrium so that it may be moved more easily.

The steam-head, which fits on the end of the steam pipe in the dome, has formed on it a double-ported vertical valve face with side guides. The main valve slides on this and has on its back, above its two ports, a face in which is cut a narrow slot that opens into the upper port in the steam-head. The auxiliary valve moves on the back of the main valve and has one small port through it. The stem of this valve is pinned to a rod which is moved by the regulator handle at the back of the boiler. The same pin also passes through a short slot in the stem of the main valve. A flat spring holds both valves on their faces

All the ports are closed when the valves are in their lowest position. When the regulator handle is moved, the auxiliary valve rises first until its slot uncovers the small port through the main valve, thus admitting steam. Further movement of the handle brings the pin against the end of the slot in the stem of the main valve, so moving it upwards and opening the large ports

The valves and head are all of gunmetal. Inv 1888–394.

144. BALANCED LOCOMOTIVE REGULATOR. Lent by N. J. Lockyer, Esq, 1922.

This is a sectioned example of the double-beat regulator valve patented by Mr Lockyer in 1913 It is designed to be perfectly balanced and to give a gradually increasing valve opening

In the usual double-beat valve the upper seating is made larger than the lower one, so that the lower valve may pass through it, consequently the valve is not perfectly balanced In the regulator shown, both valves are of the same size but are made separately The upper valve is put in position in the ordinary way from the top, while the lower valve is passed through an opening in the side of the regulator, which opening is closed by a cover The two parts are bolted together by the central spindle which also serves to lift them The valve is hollow and the steam passes through it to reach the lower opening

In order to give a more gradual opening to the valves in proportion to the lift, than is usually obtained with this form of valve, baffles are provided on them below the conical surfaces In the upper valve this takes the form of a cone, while the lower one has a cylindrical portion slightly smaller than the valve seating By this means, when the valve commences to lift, a rush of steam through the lower opening is prevented, while the upper opening increases gradually until, when both baffles are lifted clear of the seats, maximum opening is obtained.

The valve is 6·125 in diam at the seats, and the maximum lift is 1 in

Inv. 1922–110.

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145. COMBINATION LOCOMOTIVE INJECTOR. Lent by Messrs Gresham & Craven, Ltd., 1921.

This is a sectioned example of an ejector embodying features patented by Mr J Gresham in 1884 and 1887 It is a vertical, restarting injector of the self contained type, having all the control valves mounted on it, and is designed to be fitted directly to the boiler by a flange through which both the steam supply and feed-water pipes pass

Injectors are used on locomotives, in preference to other forms of feed-water pumps, owing to their simplicity, and to the fact that they act as feed-water heaters, thus reducing the stresses in the boiler which may be caused by the changes in temperature due to the introduction of the feed-water.

In the injector shown, the cones are arranged vertically with the steam nozzle at the bottom The expanding steam and delivery nozzles are screwed into the injector body, but the contracting combining cone is divided into two portions the lower half being fixed and the upper half free to slide vertically Normally the upper part rests on the lower so as to form a continuous cone, but on starting, the two parts are forced apart by the incoming steam and allow the steam to escape between them. When the water, which is raised by the partial vacuum induced by the steam jet, rises into the combining cone and condenses the steam, a vacuum is formed which draws the two parts together The water and condensed steam then escapes to the overflow through the space between the combining and delivery cones, until sufficient velocity is attained by the water to force open the back-pressure valve and enter the boiler.

The steam, water and overflow are all controlled by separate handles and a screw-down valve is fitted between the back-pressure valve and the boiler. The injector is made entirely of gunmetal. Inv. 1921–591.

146. DRAWING OF COMBINATION HOT WATER INJECTOR FOR LOCOMOTIVES. (Scale full size.) Presented by Messrs. Davies & Metcalfe, Ltd., 1921.

This shows a self-starting injector designed to operate with feed-water which would be too hot for an ordinary injector It was patented by Messrs C & R. D Metcalfe between 1899 and 1907 The use of hot feed-water renders the injector suitable for use in hot climates, and reduces the coal consumption and wear and tear of the boiler.

The injector has two steam nozzles, an annular lifting nozzle and a central forcing nozzle. The steam passes first by a mushroom valve, to the lifting nozzle, while a conical stem on the valve fits into the end of the forcing nozzle and prevents the steam from entering it until the valve has moved a short distance The valve is moved axially by a rack-and-pinion gear The lifting nozzle opens near the lower end of the combining cone which has, a short distance along it, a small gap in its sides communicating with the auxiliary overflow and also, through a non-return valve, with the water supply Above this gap the forcing nozzle terminates, and beyond this the combining cone is split and fitted with a hinged portion that opens to give a clear overflow outlet at starting, but closes and forms part of the cone when the injector is at work There is also an overflow gap at the end of the combining cone The main overflow chamber communicates with the overflow pipe through a valve which is held on its seat, when the injector is working, by means of a pivoted lever the other end of which is attached to a plunger acted on by the pressure in the delivery passage This arrangement is necessary on hot water injectors because the pressure at this point may exceed that of the atmosphere

When starting the injector the water is turned on and the steam valve slightly opened to bring the lifting nozzle into operation, water is then drawn in and escapes through the overflow The steam valve is then opened fully to bring the forcing nozzle into action, and the condensed steam gives up its energy to the water causing its velocity to increase The vacuum then formed in the combining cone closes the flap nozzle, and the overflow continues through the opening at its end The velocity of the jet increases until it is sufficient to open the back pressure valve and enter the boiler Water is also drawn in through the supplementary valve

Two screws are fitted to keep the overflow valves shut when it is desired to send steam through the injector to warm the feed-water in the tender The injector is made entirely of gunmetal Inv 1921–152

147. DRAWING OF LOCOMOTIVE EXHAUST STEAM INJECTOR. Presented by Messrs Davies & Metcalfe, Ltd, 1921.

This shows a compound injector of the form patented by Messrs J J C and R D Metcalfe in 1908 It operates mainly by exhaust steam, with a small supplementary live steam supply The use of exhaust steam is claimed to effect a saving in water and coal of some 15 per cent

An exhaust steam injector with a single jet will feed against a boiler pressure of 75 lbs per sq. in but by the addition of a second jet, in series with the first, exhaust steam at a pressure of 1 lb per sq in will force against a pressure of 120 lb The supplementary live steam jet enables it to feed against pressures up to 300 lb per sq in

In the injector shown, the exhaust steam is taken from a by-pass in the side of the engine exhaust pipe, and passes through a grease separator which removes any oil or water from it. It passes thence, through a non-return valve, into the central exhaust nozzle at the end of which it meets the feed water flowing in from a higher level When the injector starts, the steam is condensed and imparts its velocity to the jet of water and the combined jet flows forward, through the second nozzle or draft tube, into the combining nozzle, which is of the usual flap type. A high degree of vacuum is maintained along the draft tube, and at its outlet the second jet of exhaust steam is admitted as an annular jet, impinging on the outside of the moving jet, and imparting a further supply of energy to it. The jet then passes through the delivery nozzle, where the kinetic energy is converted into pressure energy, and enters the boiler through a non-return valve.

The supplementary nozzle is placed in the centre of the casing at the entrance to the main exhaust nozzle; a small central jet is provided for the supplementary steam, and an annular jet, surrounding the central one, supplies live steam for working the injector when no exhaust steam is available. The water regulation is effected by moving the exhaust steam nozzle axially by means of an eccentric pin and external handle. A combined steam and delivery fitting, placed on the back of the boiler, contains a check valve and the two live steam valves The valve by which the exhaust steam enters the injector may be held closed by a cam when necessary. Inv. 1921–154

148. MODEL OF RAMSBOTTOM'S WATER-SCOOP TENDER. (Scale 1 : 6.) Lent by J. Ramsbottom, Esq., 1893.

This represents a locomotive tender fitted with Ramsbottom's arrangement for picking up the feed-water while a train is running, an arrangement introduced in the year 1860, on the London and North Western Railway, and now adopted on many other lines

A cast iron trough, 440 yd. long, 18 in wide, and 6 in deep, cast in 6 ft. lengths and jointed with india-rubber cord, is placed between the rails and secured to the sleepers. Between the ends of this trough the rails dip about 6 in , so that the water-lifting arrangement clears the ends of the trough but dips into it for the rest of its length.

From the bottom of the tender a large rectangular pipe passes to within 18 in of the trough, and is provided with a continuation finishing in the form of a scoop 10 in wide and 2 in deep, which is carried on a horizontal axis round which it can be rotated so as to be well clear of the road when not in use The model shows the delivery pipe entering the floor of the tender and being there closed by a flap valve, but in practice the pipe is usually carried to the top of the tender and then turned downward, so dispensing with the use of a valve The extra lift thus entailed is not of importance, as at a speed of 22 miles per hour the scoop picks up its full quantity of 400 gal in passing over the trough Inv 1893-238 29,809.

ROLLING STOCK.

The passenger traffic which unexpectedly developed on the first railway was accommodated by placing coach bodies on wagon under-frames; and, following the stage coach arrangement, seats were booked before starting, luggage was carried on the top of the vehicle, and frequently a guard was seated beside it outside (*see* Nos. 152 and 157). As traffic increased the form of passenger vehicle thus introduced was adhered to except that additional accommodation was obtained by providing more compartments in the greater length possible on a railway, and this is the construction still generally followed here; in America, however, the railway car appears to have been developed from the steamer saloon, and is characterised by the vestibule construction. In the stage coach traffic the inside passengers, representing the first-class, paid the highest fare, the outside passengers or second-class being taken at a reduced rate, while the poor could not avail themselves of the service. With the early railways first-class passengers were originally provided for, then a cheaper accommodation was added for the second, while the third-class, taken at a rate established by Parliament, were most unwillingly accommodated by the companies who, for many years, displayed considerable ingenuity in attempting to discourage cheap travelling. Some of the earliest third-class vehicles consisted of open wagons without seats, and improvement was so slow that even in 1845 many coaches had neither windows nor lamps, about 1870, however, it began to be generally realised that it was upon the popular traffic that the receipts depended, the amount of dead weight carried and the capital invested in superior coaches being out of proportion to the paying load conveyed by them even at the higher rate charged. In carriage construction the increased length and capacity of the vehicles have been followed by the use of rolled-steel beams in place of wood for the under-frames, and by the use of bogies instead of a long rigid wheel-base. The buffers originally used were simply pads strengthened by metal bands, while the carriages were hooked together loosely like goods wagons, the present system of close coupling being introduced by Mr. Henry Booth, who, in 1836, patented the now general right and left threaded screw coupling; automatic couplings by which the vehicles of a train can be connected together or detached without a man having to pass between them have been very generally adopted in America and the matter has received much attention in England, where, however, the double buffers used in place of the American central buffer add to the difficulty of the problem.

The earliest coal wagons were no larger than those used with horse haulage; general merchandise was carried on four-wheeled flat trucks, but wagons with sides were in general use about 1840. Traffic and terminal conditions in this country have caused the retention of low-capacity wagons for normal use, but in America large bogie wagons were adopted many years ago. Steel wagons of about 10 tons capacity are now much used, while for mineral traffic high-capacity wagons, holding up to 50 tons, are being employed where possible, as they increase the ratio of paying load to gross load, thus increasing the earning power of the train and at the same time reducing its length.

The first street tramway was opened in America in 1832, and they were introduced into England by Mr. G. F. Train in 1860. Horse traction was general until about 1883, although some lines were worked

by cables or by steam or compressed air locomotives. Since that time the horse has been gradually displaced by the system in which mechanical power is electrically transmitted to the vehicles. The omnibus type of body, adopted at the beginning, has persisted, except for open vehicles where transverse seats are used.

For carrying traffic safely at a high speed the power of rapidly arresting the motion of a train is so essential that the early hand brakes, applied to a few vehicles only, have been replaced by those simultaneously applied to all the wheels of the train so as to secure the maximum of retarding action. Chains or shafting were at first used to transmit the power to these continuous brakes, but air pressure, introduced in 1870, is now the means generally employed. These air brakes come into action automatically, should a pipe or coupling break, and they will stop a train moving at 50 miles an hour within a distance of 1,000 to 1,500 ft, depending upon the state of the rails. Recent improvements render the brakes so quick-acting as to obviate danger arising from delay in the application of the brakes to the rear vehicles of a long train. Continuous brakes are now being applied to fast goods as well as to passenger trains.

CARRIAGES AND WAGONS.

149. MODEL OF TIMBER RAILWAY AND QUARRY TRUCK. (Scale 1 : 10) Made in the Museum, 1904. Plate IX, No. 1.

The models shown were made from the drawings published by Desaguliers in 1734 as representing the arrangements used by Ralph Allen to convey stone from his quarries to the River Avon, near Bath, which are described as "a great improvement on some carriages and waggon-ways made use of at the coal mines near Newcastle" The quarries were situated 1·5 miles from the river and 500 ft. above its level, the line thus having an average gradient of 1 in 16.

The wagon-way consisted of rectangular rails of oak laid along the ground and probably connected by cross ties, covered with ballast to prevent damage from the horses' feet, the rails were 5 in wide by 6 in deep, and were laid to an inside gauge of 3·75 ft

The truck was carried on four cast iron wheels having deep flanges on the inner edge to prevent them from leaving the rails, while the axles revolved in brass bearings secured to transverse beams below the floor, one wheel was fixed on each axle, the other being free to revolve independently The loaded truck descended by gravitation and was controlled by a man walking behind it, who could retard the four wheels separately This was accomplished at each rear wheel by a wooden brake block, pressed on to the rim by a lever which was drawn down by a chain wound on a drum, while the drum was rotated by a handspike and retained by a ratchet wheel, the front wheels were braked by actually locking them, two iron bolts being provided which could be thrust between their spokes by means of levers and rods operated from the rear of the truck

The return journey was made by two horses, the brake levers being removed and placed inside the truck, the sides of the truck were also removable. The truck measured 12 ft long by 3·5 ft wide and had a wheel-base of 6 ft. The wheels were 19 in diam, 6·5 in wide on the tread, and had flanges 3 in. wide and 1 in thick, the axles were 3 in. diam The load carried was four tons, and the cost of each truck was 30*l*.

Inv. 1904–14. 27,851.

150. MODEL OF RAILWAY CARRIAGE (1825). (Scale 1 : 6.) Lent by the Lancashire and Yorkshire Railway Co., 1895. Plate IX, No. 2.

This model represents the "Experiment," the first passenger carriage ever used on a railway It was constructed in 1825 for use on the Stockton and Darlington Railway, a line which had then been recently constructed for goods traffic.

The carriage consisted of a body similar to that of an ordinary stage coach, supported on two longitudinal beams, the ends of which served as buffers. It was carried on four wheels 34 in. diam., with a wheel-base of 51 in., the axles running in fixed bearings without springs. The carriage had an overall length of 12 ft., a width of 5·25 ft., and a height from the rails of 7 ft.

A copy of an original handbill (adjacent) shows that the "Experiment" commenced running daily on the 10th of October, 1825, the fare charged between Stockton and Darlington being one shilling. Inv. 1895-55 S.M. 809.

151. VIEWS OF THE LIVERPOOL AND MANCHESTER RAILWAY IN 1831.

These are printed on a cotton handkerchief, in the centre of which is a careful representation of the leading locomotive of the period, it is of the "Samson" class with inside cylinders and four coupled wheels. On the side of the engine is seen a large hand-power feed pump, an arrangement that was for some years provided on this line, to prevent delay should the engine-driven pump fail

On the handkerchief are twelve other views relating to this line, as follows:— Train of 1st Class Carriages; Train of 2nd Class Carriages, Train of Wagons with Goods, &c; Train of Carriages with Cattle; Railway Office, Liverpool; Entrance into Manchester across Water-street, Viaduct across the Sankey Valley, Rainhill Bridge; End of the tunnel towards Wapping, Liverpool, Moorish Arch looking from the tunnel, View near Liverpool looking towards Manchester, Parkside, the station where Mr Huskisson was fatally injured on the opening day

These views are two or three years earlier than those shown in No. 152, by comparing with which it will be seen that the second-class accommodation had in the interval been improved by the provision of a roof Inv. 1897-44

152. PRINTS OF EARLY ROLLING-STOCK OF THE LIVERPOOL AND MANCHESTER RAILWAY.

These aquatints, published in 1833-34, record with considerable detail the arrangement of our early trains

The first-class carriages shown are obvious adaptations of the stage coach design, and have distinguishing names such as "Times," "Traveller," etc, just as when used on the road The first-class train has a guard on the box-seat of the foremost coach, and another on a similar seat on the hindmost Luggage is carried on the roofs, and an open truck is provided in which an ordinary private carriage is conveyed, with its occupants in it The second-class carriages have low sides and a light awning supported considerably above them on uprights, while bench seats were fitted. The third-class carriages were simply open wagons without seats, but provided with holes in the floor to carry off the rain-water that collected Cattle, sheep and pigs are shown carried in trucks with open-railed sides, those for sheep being two-storied, the horse truck closely resembles those still in use The goods trucks are short four-wheeled vehicles without sides, while for conveying timber two trucks are used, the requisite length being obtained by leaving considerable space between the buffer-beams

One of the engines shown is of the "Rocket" type, and is called the "North Star"; it had outside cylinders 11 in diam by 16 in stroke, with single drivers 60 in diam The tender is a four-wheeled truck, containing coal and a large water-barrel The other engine, "Jupiter," was of the "Planet" class, with cylinders 11 in diam by 16 in stroke, and 5 ft drivers, but as it is shown with four equal wheels, it is probable that the engine represents one of the "Samson." class with cylinders 14 in diam by 16 in stroke, and four-coupled wheels 54 in. diam, but that the artist has omitted the coupling-rods Its tender has a rectangular iron tank instead of the earlier wooden barrel

Inv 1895-110 S M 1,472, & 1896-135.

153. PHOTOGRAPHS OF EARLY RAILWAY CARRIAGES. Presented by the London and South Western Railway Co, 1896.

These vehicles, which are still in existence (*see* Nos 154 and 158), were used on the Bodmin and Wadebridge Railway, Cornwall, at, or shortly after, its opening in 1834, and remained the only passenger carriages of the line till 1889, when the railway, which had remained isolated, was modernised.

The Bodmin and Wadebridge Railway was a mineral line, about 15 miles in total length and of standard gauge, built in 1834 as a private undertaking at a total cost of 35,000*l*. It was financially unsuccessful and, although purchased by

the London and South Western Railway in 1846, remained in its primitive state till 1889, when the Great Western connected with it at Bodmin; in 1896 the London and South Western joined it to their system at Wadebridge. Till its conversion to modern arrangements, the line was worked by two six-wheeled coupled locomotives, one of which was in reserve, and a number of hopper wagons together with the four passenger vehicles shown in these views, the passenger traffic was, however, confined to the 7·5 miles of line between Bodmin and Wadebridge.

The composite carriage has a central first-class compartment and a second-class compartment at each end, all upholstered in blue cloth and lighted by two lamps in the roof, together with the side windows; each compartment is 4·5 ft long, 6 ft wide, and 5·75 ft high, while the height from the rails to the top of the roof is 8·4 ft. This carriage is now preserved at Waterloo Station

The second-class carriage consists of one compartment, 10 ft long, which seats sixteen persons, while the two third-class carriages are open trucks with seats and side doors The wheels are of cast iron 25 in diam. and support the vehicles by springs; spring draw-bars are fitted, but the buffers are formed of stuffed leather pads, or else of solid wood, and the coupling was performed by slack chains only

In the frame is also a portion of an ordnance map showing the line, together with some other photographs of the rolling-stock. Inv. 1896-107

154. EARLY RAILWAY CARRIAGE (Scale 1 8) Made by Messrs. Braun & Co from information supplied by the London and South Western Railway Co, 1913.

This represents a second-class carriage built for the Bodmin and Wadebridge Railway about 1837, and used on that line until 1889 (*see* No 153)

The carriage is a box-like vehicle having two compartments with transverse seats holding 16 persons The body is 10 ft long, 6 42 ft wide, and 5·87 ft high at the middle; it is framed in oak with pine panels, while lights are provided in the doors only The seats are of plain wood, and a small oil lamp is placed at the centre of the roof The underframe is of oak, securely stayed and bolted, and is supported on four cast iron wheels with wrought iron tires 25 in diam The horn plates are stayed to the frame, and the spring ends work between guides which have inclined slots to accommodate the spring pins The buffers are of solid wood with iron bands round their outer ends

A loose chain at one end and a hook at the other end are provided for coupling Two footboards are fitted at each side The wheel-base is 6·33 ft, and the carriage weighs 2·27 tons

The original carriage is preserved at Kingston-on-Thames Station.

Inv. 1913-484. S M 413

155. PHOTOGRAPH OF EARLY RAILWAY CARRIAGE. Presented by the Dublin and South Eastern Railway Co, 1907.

This carriage was built in 1837 for the passenger traffic on the Dublin and Kingstown Railway, and was used occasionally until 1894. The line opened in 1834 was about 7 miles long, and was the first railway opened in Ireland, it was originally laid to the 4·7 ft gauge, but this was altered to 5·25 ft in 1854-5. The line now forms part of the Dublin and South Eastern Railway system The carriage was for second-class passengers and has four compartments, three of them holding eight persons and the other one only four. It has a roof supported on iron pillars The ends are closed but the sides are open Loose cushions were provided for the seats The carriage body is 17·2 ft long and 6·7 ft wide, it is mounted on four wheels 41 in diam. with a wheel-base of 10·5 ft. Side buffers are now fitted, but when built central buffers were used The carriage is shown standing on some of the original rails; these were of wrought iron, bull-headed, and weighed 40 lb per yd. when new They were keyed into cast-iron chairs secured to granite blocks Inv. 1907-26.

156. PHOTOGRAPH OF PASSENGER CARRIAGE OF 1838. Presented by the South Eastern Railway Co., 1894.

This composite carriage was built in 1838, and used by the Duke of Wellington for his journeys on the Canterbury and Whitstable, now part of the South Eastern and Chatham, Railway.

The length of the earlier coach, over buffer beams, is 22 ft., and of the later 24·2 ft.; the wheel-base of the former is 11 ft. and of the latter 12 ft. The vehicles are built entirely of teak, with double roofs covered with painted canvas.
Inv. 1883–23.

163. MODEL OF DOUBLE-HOPPER COAL WAGON. (Scale 1 : 16.) Lent by Messrs. Sheffield & Twinberrow, 1905.

This represents a large steel wagon of the form proposed and patented by Messrs. G. H Sheffield and J D. Twinberrow in 1898–99.

The use of such wagons is estimated to increase the ratio of paying load to gross load and the earning power of a train of given weight by about 20 per cent., at the same time reducing the length of the train There are, however, some objections to their general use, chiefly in connection with the handling of goods and the alteration required in terminal structures, but high capacity wagons of various types are now being used on several railways particularly for mineral traffic

The wagon is formed as a double hopper with horizontal sliding doors and is carried on two four-wheeled bogies The sides are in the form of deep plate girders with angle-iron booms, tapered at the ends and attached to the headstocks These serve as the main frames, being stiffened and tied together by the ends of the hoppers and also by transverse bulb bars at the top, while a stiff transom is built up over the centre of each bogie There is also a hollow longitudinal tie which accommodates the draw-bar The hopper doors are mounted on rollers running on angles forming a light framework which supports the hand gearing for operating them The bogies have pressed steel frames and wheels 3 ft diam with a wheel-base of 5 ft, the axles being fitted with helical springs They have no central pivot, but the load is carried by four semi-elliptical springs attached to the wagon body and bedded on bearing surfaces formed on the bogie frames Their motion is controlled by four horizontal spring links, one at each corner, passing through lugs on the wagon and bogie frames The buffers are arranged so as to equalise the pressures when passing round curves The two stems pass through the headstock and are united by two cross beams, forming a frame which is pivoted just within the headstock, tension and compression springs are fitted to the inner cross beam, and the two headstocks are connected by a draw-bar to which the compression springs are attached The buffers are constructed to act as automatic couplings, each being provided with a pair of hinged arms which embrace the corresponding buffers of the next wagon The arms have short backward extensions which are held outward by two lugs projecting from a central boss, which is fixed to a movable spindle normally held by a spring so as to project from the face of the buffer and at the same time to release the arms When one buffer head comes into contact with another, the arms embrace it, and the spindle is pushed in, so locking them The spindles can be rotated by a hand rod from either side to release the couplings

The wagon is 42 ft long, 8 ft wide, and 9 ft high, holds 36 tons of coal and has a tare weight of 14 tons, the load on each axle is 12·5 tons The bogie centres are 32 ft apart and the total wheel-base is 37 ft

Wagons of this form, holding 40 tons of coal, but without the automatic couplings, are in use on the North Eastern Railway Inv. 1905–3

164. MODEL OF TEN-TON WAGON. (Scale 1 · 8.) Lent by the Great Western Railway Co, 1908.

This represents a type of wagon used on the Great Western Railway; it is built entirely of steel and is fitted with the form of either-side brake patented by Messrs W Dean and G J Churchward in 1902

The wagon underframe is built up of steel channel and angle-bars, and the side and end plates are secured to it by angles and vertical posts, there is a hinged door at the middle of each side The buffer stems engage with the ends of transverse springs, the buckles of which form links in the draw-bar The brake gear consists of the usual pair of brake-blocks on one side of the wagon, suspended by links and connected by hinged rods with short levers on the brake shaft The brake shaft has a vertical lever on it, and a longitudinal motion of the end of this applies the brakes, a spring pulling in the opposite direction tending to keep them off the wheels The gear for working the brakes from either side consists of a pair of transverse shafts carried in bearings below the frame, one at each end of the wagon, and each having a short hand lever fixed on one end of it; these two shafts are coupled together by levers and rods, and one of them carries a loose

ratchet toothed sector, a point on which is connected with the brake lever by two rods and an intermediate lever for increasing the power Fixed to the shaft by the side of the sector is an upward projecting lever that engages with a lug on the sector so as to turn it and apply the brakes when either of the hand levers is depressed. The brakes are held on by a spring pawl engaging with the teeth of the sector, but this is knocked off by the top end of the lever when the hand levers are raised to release the brakes The brake-blocks have lugs on them embracing the wheel flanges, and safety slings are fitted to the brake-rods to prevent them falling to the ground if any part should fail

The wagon runs on four wheels 36·5 in. diam , with a wheel-base of 9 ft , and has an overall length of 19 ft , its tare weight is 5·4 tons. In the model the floor plates are removable in order to show the construction of the framework.

Inv, 1908–7.

165. MODELS OF CARRIAGE AND WAGON BOGIES. (Scale 1 · 8.) Lent by the Leeds Forge Company, 1901

The employment of long railway carriages and wagons was only rendered possible by the adoption of the bogie truck, upon which the two ends of the vehicle are supported by swivel connections, which reduce the rigid wheel-base to that of the bogie, so that it is even less than that of the short four-wheeled trucks formerly invariably used

The models represent two model bogies, manufactured upon the system patented by Mr Samson Fox in 1885–96, in which the framework is made up of steel plate, pressed while hot, into trough-like forms, which give the desired strength and the means of attachment without the use of angle-iron or much riveting In this way it is stated that an underframe is made with one-fourth the number of pieces and one-third of the rivets that are required in a similar frame of the usual channel and angle-iron construction , the consequent reduction in weight is such that coal wagons carrying 30 tons have been built of a tare weight of 12 8 tons

The larger model represents a standard carriage bogie for a line of 5·5 ft gauge Each end of the carriage underframe is carried on a bolster by a central swivel plate and side bearings , the bolster is supported by six helical springs, on a beam which is suspended from the bogie frame, so that it can swing transversely ; the bogie frame itself is suspended from the axle-boxes by plate springs and end washers of rubber

The smaller model shows a wagon bogie for the standard gauge of 4·7 ft. Each end of the wagon underframe is supported by bearing plates on the side frames of the bogie, and by a central pivot fitting into a fixed plate on the transoms , the weight of the bogie is transmitted to the tops of the axle-boxes by plate springs, whose ends are held by lugs fixed to the frames Inv 1901–15.

MONORAIL VEHICLES.

166. MODEL OF GYROSTATIC MONORAIL CAR. (Scale 1 8) Lent by Louis Brennan, Esq , C.B., 1914

The use of the gyroscope, as a means of enabling an unstable vehicle to remain upright when standing or running on a single rail, was patented by Mr Brennan in 1903 and 1909 The model illustrates the arrangement of the gyroscopes and one method of automatic control, but the full-sized car, built in 1909, has much more elaborate controlling mechanism

There are two gyroscopes rotated by electric motors, in opposite directions about horizontal axes situated normally athwart the car These gyroscopes are mounted in frames which are geared together and are capable of turning about vertical pivots carried at the ends of a transverse frame which is itself mounted on an axis parallel with the length of the car. Two gyroscopes are necessary to enable the car to run in either direction on curves of any radius When the car is standing upright with the gyroscopes running, a couple tending to overturn it causes the gyroscopes (which with their frames are called gyrostats) to turn or precess in opposite directions about their vertical axes, and in order to restore the car to its equilibrium position it is necessary to accelerate this precessional motion which action brings into play a righting couple

The outer end of each gyroscope spindle carries a roller driven by gearing at a reduced speed, while each gyrostat has an outwardly projecting arm along which, slides a block provided with a downwardly projecting pin On the body of the car

are fixed horizontal surfaces, against which the spindle rollers can react by friction when pressed into rolling contact, so as to exert a force tending to accelerate the precession of the gyrostats, which force is substantially proportional to the reaction between the roller and the surface. On one side of the central position the downwardly projecting pins are guided, as regards radial motion, by cam-surfaces forming a circular groove, and on the other side of the central position the outer cam-surface is curved inwards so as to form a spiral guide, the depth of which is limited by a ledge There is also another cam-surface on this side, forming a groove with the edge of the ledge and when the pin is in either groove the gyrostat roller can come into contact with its co-operating surface. The cam-surfaces are arranged so that the acceleration in one direction is caused by the spindle of one gyrostat, and that in the opposite direction is caused by the spindle of the other gyrostat The two pivoted frames are connected together by a helical spring attached to upright brackets, placed on the transverse axis but beyond the pivot centres, so that when the gyrostats precess, the spring tension also introduces an accelerating force which is sensibly proportional to the displacement.

The operation of the mechanism is as follows :—

On the application of a tilting couple to the vehicle, precession of the gyrostats takes place and is assisted by the spring and by one of the spindle rollers which comes into contact with its accelerating surface During the righting motion the gyrostats move away from the central position and the projecting pin of the other gyrostat is lifted clear of its ledge and is moved inward by the spiral guide When the equilibrium position has been passed, the action of the roller ceases and the pin of the other gyrostat is brought into contact with the ledge, so that the return motion of the gyrostats is at first retarded by the frictional contact At a certain point in this movement the pin slips off the ledge into the groove, retardation ceases, and the roller on this side comes into play, so that accelerating force is again applied accompanied by the return of the gyrostats to their central position and of the vehicle towards its equilibrium position Any slight deflection is now corrected by a repetition of this process, and the amplitude of the oscillations is quickly reduced to zero

The car is mounted on four grooved wheels arranged as two bogies the frames of which have horizontal as well as vertical pivots The driving motors are mounted over the outer wheels, with which they are connected by gearing, and the axles are connected by coupling rods Current is supplied by accumulators carried in the car

Mr Brennan's full-sized car is 40 ft long, 10 ft, wide weighs 22 tons and carries a load of from 10 to 15 tons The gyroscopes are 42 in diam , and each weighs 0·75 tons ; they run in a vacuum at a speed of 3,000 revs per min The control is by compressed air and the current is supplied by two petrol electric generating sets. Inv. 1914–552.

167. GYROSTATIC MONORAIL CAR. Presented by Mons P Schilowsky, 1914.

This model shows a monorail car stabilised by a gyroscope which is controlled in the manner patented by Mr. Schilowsky in 1909. The arrangement of the gyroscope itself is, however, that patented by Mr R Scherl in 1908 A single gyroscope, with its axle vertical, is carried in a frame which is pivoted on the car about a horizontal transverse axis ; this axis is placed below the centre of gravity of the gyroscope and frame, or gyrostat, so that the latter is unstably mounted on the car It is claimed that this arrangement of gyroscope enables the car to travel round curves of ordinary radius without the use of a second gyroscope (*see* No 166), that the gyroscope need only run at a moderate speed, and that it is more easily controlled

When the gyroscope is spinning, the car will balance itself on the rail, and the application of a force tending to overturn it results in the gyrostat precessing about its horizontal axis As soon as the gyrostat leaves the central position, its weight automatically accelerates the precession, brings into action a righting moment, and brings the car back to and beyond its original position The gyrostat does not, therefore, precess in one direction, as a neutrally suspended one would do, but oscillates about its central position, causing the car to oscillate similarly but with a phase difference of 90 deg If the gyrostat were left to itself these oscillations would increase in amplitude until the car fell over, and permanent stability can only be maintained by applying additional accelerating forces, by means of suitable mechanism, so as to damp out the oscillations and bring the gyrostat back to its central position when the car reaches its equilibrium position.

The precession of the gyrostat is controlled by a heavy pendulum mounted on the car so that it can swing in a traverse plane; this bears against a flexible cord fixed at one end and connected at the other end with the long arm of a horizontal lever which is pivoted on the pillar supporting the gyrostat The opposite and short arm of the lever has pivoted on it a vertical toothed quadrant normally held by a spring just out of contact with a pinion mounted on the top of the gyrostat and driven from its spindle at a reduced speed. The quadrant is held in the vertical position by a rod and springs, against the pressure of which it can move laterally A similar mechanism on the opposite side of the car acts in conjunction with another pinion rotating in the opposite direction.

When the car is upright the pendulums hang vertically and the quadrants are clear of the pinions. When, however, the car leans to one side, the gyrostat precesses in the corresponding direction, and one pendulum bears against its cord and so raises its quadrant into engagement with the pinion. This imparts to the gyrostat an additional force tending to accelerate the precession, with the result that the car rights itself and moves slightly beyond its equilibrium position. The opposite pendulum then brings its quadrant into action and the oscillations of car and gyrostat are rapidly reduced to zero If a load be placed on one side of the car, that side will rise until the centre of gravity is vertically over the rail, the gyrostat retaining its central position. Similarly on entering a curve, centrifugal force acting on the inner pendulum brings its quadrant into gear and causes the gyrostat to precess so that its reaction turns the car inwards to balance the centrifugal force. The quadrants can be adjusted in position or put out of action when necessary

The car is mounted on a pair of two-wheeled bogies provided with vertical and horizontal freedom, and the wheels of one are driven by an electric motor; the gyroscope is also motor driven. It is intended that a train should be made up of ordinary cars and gyro-cars alternately, the connections being made with the special form of coupling shown on the model. Inv 1914–185 S M 443.

TRAMWAY VEHICLES.

168. DRAWING OF FIRST TRAMCAR USED IN AMERICA (1832). (Scale 1 16)

This represents the first horse car built for a street tramway, it was constructed by Mr. John Stephenson in 1831 for the New York and Haarlem street railway, which was opened in 1832. The car had a coach body with three compartments, and this was suspended by leather straps from a separate springless underframe carried on four wheels The driver's seat was on the roof The wheels were 3 ft. diam and the wheel-base was 5 ft, the body was 14·3 ft long and 5 ft high Inv 1912–39.

169. MODELS OF TRAMCARS. (Scale 1 : 24.) Presented by Z. Eastman, Esq., 1868.

The two models show a form of street tramcar introduced by Mr Eastman in 1804 The tramway required consists of two shallow gutters in which the wheels run, thus resembling the early plateways and Train's tramway. The car wheels are without flanges, but have slightly rounded threads.

The axles are carried on central pins and races so that they can swivel, and the axles, whether two or three in number, are connected together by cross-bars or by segmental gear in such a way as to cause them to radiate horizontally when the horse pole is pulled sideways on passing a curve. Inv. 1868–16.

170. EARLY ELECTRIC TRAMCAR TRUCK. Presented by the South Staffordshire Tramway Co, 1912.

This is a four-wheeled tramcar truck built in 1892 by Mr. A. Dickinson for the South Staffordshire tramway; this was the second electric tramway opened in this country with the overhead conductor system of current collection, and the first of the kind with British equipment. The line is of 3·5 ft. gauge and was originally worked by steam locomotives.

The truck has a frame composed of two pressed steel side-members, connected at the ends by angle-irons and at the centre by a transverse channel bar; this is carried on helical springs placed on the tops of the axle-boxes, and the car body was mounted on eight springs placed on the top of the side frames

The two motors, made by Messrs Parker of Wolverhampton, are of the open type and have two-pole magnets, each pole being at the middle of a horizontal bar with a field coil on each side of it The magnet bars are connected at the ends by yoke pieces having projecting pillars on both sides, to which are attached cast iron side frames in which the bearings for the armature shaft and running axles are formed The inner ends of the motors are supported between helical springs resting on the central frame bar, and the armature shafts are connected with the axles by double helical steel gearing with a ratio of 4.1 The armatures have smooth cores and are drum wound; their undersides are partially protected by brass shields bolted to the lower poles The brush holders are wooden levers pivoted at their lower ends on insulated studs, and having for brushes pieces of carbon 20 mm diam placed lengthwise along the commutator and held in brass V blocks bolted to the levers, the upper ends of which were drawn together by india-rubber bands The four field coils of each motor are connected in parallel and in series with the armature, the controller was so arranged that either motor could be used separately or both in parallel, the necessary varying resistance being included in the circuit The line pressure was 350 volts and the motors were rated at 15 h p each, the speed attained on trial was 36 miles an hour

The truck has steel wheels 33 in diam and a wheel-base of 6 ft, brakes were fitted on both sides of the wheels. The car was constructed to carry 40 passengers, was 22 ft. long and 5·8 ft wide, its weight unloaded was 6·65 tons

Inv. 1912–203.

171. MODEL OF MAXIMUM TRACTION TRUCK. (Scale 1 · 4.) Made by the J. G Brill Co.

This represents an electric tramcar underframe mounted on a pair of the single motor trucks patented by Messrs G. M and J A Brill between 1893 and 1901 The so-called maximum traction truck was designed for use with large bogie cars, where only one motor is employed on each truck, and in order to utilise a large proportion of the adhesive weight of the car the load is concentrated almost directly over one of the axles, which is driven by the motor, the wheels on the other axle of the truck, owing to their wide swing, are made small enough to pass under a car body of normal height

The truck has one-piece forged steel side frames which are securely braced together by two cross-bars The frames rest on helical springs placed on the tops of the axle-boxes, and the car body rests on side bearings only, which each consist of a head-piece mounted on two posts passing through a horizontal bracket projecting from the top of the driving axle-box guides, and also through the main frame; collars on these posts are supported on conical springs resting on the frame The position of the bearings is such that 75 per cent. of the load is carried on the driving axle.

The bearing heads are loosely fitted for equalisation, and they have anti-friction plates on their upper surfaces and rollers at their outer sides which bear against the inner surfaces of the curved angle-plates attached to the side sills of the car The tractive force is transmitted to the car frame by a vertical pin attached to a cross sill, and the lower end of this pin passes through a block that slides in a curved guide bolted to the truck; the guide has a radius struck from the virtual turning centre of the truck, which is at a point 6 in from the driving axle on the inner side In order to prevent derailment on curves a spring pillar, mounted at the middle of the truck cross-bar near the trailing axle, has its upper end bearing against a doubly inclined plate fixed to the car cross sill, so that the spring is compressed and the load on the small wheels increased, when the truck swings round A 25 h p, single-geared, enclosed motor is carried between the axles, one end being mounted on the driving axle and the other bolted to a cross-bar supported by springs on the truck side frames The wheels are of chilled cast iron 30 in and 20 in diam, and the axle-boxes are self-oiling and dustproof. The brake-shoes embrace both tread and flange of the tires, and are hung by double links from brackets on the truck cross-bars; they are connected in pairs by cross beams and are applied to the tires by levers and rods. The blocks on the small wheels come into action first through the medium of springs, and the others when these springs are sufficiently compressed, other springs hold the brakes off The brake levers at each side of the truck are coupled together by a curved bar upon which the brake rigging on the car acts through a rod ending in a roller fork, this allows the trucks to turn on curves without disturbing the brake adjustment.

The car underframe is a rectangular wooden framework strengthened by several cross sills, cross-braced at the centre, and provided with doors in the floor over the motors. The end platforms are supported by knees or cantilevers bolted to the main frame, and curved angle-iron buffer beams are fitted at the ends of these. Draw-bars are provided for use with trailer cars, and these bars can be housed under the platforms when not in use. Rail scrapers, which can be raised or lowered, are mounted below the platforms at each end.

The car is for the standard gauge of 4·7 ft., each truck has a wheel-base of 4 ft., and the total wheel-base is 12·5 ft The small wheels of the trucks are placed towards the centre of the car. The length of the car body is 20 ft. and the overall length is 29·5 ft. Each truck with its motor weighs about 2 tons.

Inv. 1911–65. S.M. 294.

172. MODEL OF HIGH-SPEED TRUCK. (Scale 1 : 4.) Made by the J. G. Brill Co.

This represents a type of railway truck or bogie patented by Messrs G. M. and J A. Brill in 1898 and 1899 It is much used in the United States for inter-urban electric services, where single cars are run at speeds as high as 60 miles an hour, but it is also considerably employed on ordinary steam railways The features of the design are the method of equalising the load on the wheels through three sets of springs, and the cushioned side swing of the bolster which steadies the motion on curves and prevents derailment, especially where shallow wheel flanges are used

The truck has two side frames, each formed as a single steel forging, and these are connected together by T-bars at the ends and a pair of angle-iron transoms at the centre. The four axle-box horns on each frame are stayed by a continuous angle-iron bar The load is carried on a wooden bolster with a centre pivot and side bearing plates, which is fitted between the transoms, the bolster is mounted on four elliptical springs, two at each end, which rest on a lower wooden beam enclosed by a pair of Z-bars, that connect together two equalising bars suspended from the frames by spring links placed as near as possible to the axle-boxes On curves, the bolster and equalising bars move sideways, causing the links to swing on the frames and at the same time compressing their springs. Helical springs are placed between the frames and the tops of the axle-boxes, so that the spring-base is equal to the wheel-base, and the application of the brakes does not result in excessive tipping of the truck The brake-blocks are suspended by double links from the end bars of the frame, they are connected by cross-bars, held off by springs, and applied to the wheels by levers mounted at the centre of the truck Renewable shoes are attached to the brake-blocks by wedges, and in order to preserve the adjustment on curves, the brake-levers at each side are connected together through a pair of rods by a curved cross-bar to which the brake rigging of the car is attached The whole arrangement leaves a clear space for the motors The axle-boxes are self-oiling and dustproof

The truck is driven by two single-geared motors placed between the axles and the bolster, one end of a motor is mounted directly on the axle and the other end is bolted to a cross-bar supported on springs on the transom The motors on a truck of the size shown would be of 25–35 h p each; it is suitable for loaded cars weighing up to 20 tons and can be run at speeds up to 50 miles an hour The wheels are of chilled cast iron 33 in diam, and the wheel-base is 6 ft.

Inv 1911–64. S M 671.

173. MODEL OF ELECTRIC TRAMWAY TRUCK. (Scale 1 : 4.) Made by the J. G. Brill Co.

This represents a type of equal-wheeled, centre pivot, bogie truck, patented by Messrs G M. and J A Brill in 1898 and 1900 It is largely used in America, and to some extent in this country, under long tramcars for city and suburban services where speeds up to 30 miles an hour are attained The sharp curves on such lines necessitate a short wheel base, and this involves placing the motors beyond the axles, and supporting them on the ends of the truck The features of the design are the method of equalising the load on the wheels through three sets of springs, and the cushioned side swing of the bolster which steadies the motion on curves and prevents derailment

The truck has two side frames, each a single steel forging, and these are connected together by angle-bars at the ends, bent to give room for the motors, and a pair of angle-iron transoms at the centre The axle-box horns are connected by an angle-iron bar at each side. The load is carried on a bolster composed of

two steel plates, with wood between, and having a centre pivot and adjustable side bearings attached to it. The ends of the lower bolster plate are bolted to the centres of two semi-elliptical springs, the ends of which are hung from the side frames by spring links placed as near as possible to the axle-boxes. The motion of the bolster on curves is cushioned by the springs of these links when they swing laterally. Compound helical springs are fitted between the frames and the tops of the axle-boxes. The brake blocks are applied to the inner sides of the wheels, and are suspended by double links from the transoms; they are connected by cross-bars which are acted upon by central adjustable levers to apply the brakes and by springs to release them. The renewable brake shoes are attached to the blocks by wedges, and they embrace both the treads and flanges of the tires so as to wear them equally.

The truck is driven by two single-geared motors of 25 h p each; one end of a motor is mounted directly on the axle, and the other end is bolted to a cross-bar supported on springs on the frame ends. The wheels are of chilled cast iron 33 in diam, and the wheel base is 4 ft The truck shown is suitable for a car weighing 17 tons, with equipment and passengers. Inv. 1911–63 S.M. 293.

174. MODEL OF TRAMCAR TRUCK WITH RADIAL AXLES. (Scale 1 : 6.) Lent by the Warner International and Overseas Engineering Co., Ltd., 1912.

This represents an electric tramcar truck fitted with the arrangement of non-parallel axles patented by Mr. J. S. Warner in 1905 and 1908 In this system all the axles of a vehicle are so mounted that while parallel to one another on a straight track they are free to set themselves radially to the track when rounding curves This method of mounting allows the vehicle to pass smoothly round curves, shocks and oscillations are reduced, thus minimising the wear of rails and tires, giving the vehicle a much steadier motion and requiring less tractive effort.

The truck is built up of steel channel-bars, cross-braced at the ends and at the centre, where there are fitted two vertical pins Each axle is mounted in bearings in a separate open frame, the latter being pivoted to the main frame by one of the pins Opposite each axle end two brackets project downward from the main frame and are connected at the bottom by a cross-bar This cross-bar is suspended from the axle frame by two links, one on each side of the axle-box, the link pins being set radially to the pivot pins The upper parts of the links are surrounded by the helical bearing springs, which are supported by lugs on the axle boxes. The effect of this suspension is that on a curve the axles are set radially by the action of the rails on the wheel flanges and the links in swinging raise the vehicle slightly, giving a gravitational control which restores the axle to its normal position on leaving the curve No bearing pressure comes on the centre pivots

The brake gear is mounted on the axle frames and has brake blocks on the inner sides of the wheels only; the connections with the main frame are made by pin joints directly under the turning pivots, so that the gear is not affected when the frames turn. The car body is carried on eight helical springs suspended below the main frame side sills The truck is fitted with a safety guard under each platform This consists of a flat-hinged guard normally held horizontally, but so connected with a hanging flap at the end of the platform that it is lowered on to the rails when the flap is pushed backward by an obstacle The guard is restored by a pedal on the platform

The model shown represents a four-wheeled tramcar truck for the standard gauge, with wheels 30 in diam and a wheel base of 9 ft. The system is applicable to all kinds of railway or tramway rolling-stock and especially to large bogie vehicles. Inv 1912–27

WHEELS.

175. EARLY CAST IRON WAGON WHEEL. Presented by H.G. the Duke of Rutland, K.G., 1904.

The wheels of the wagons used on the early wooden railways were described in 1676 as "rowlets fitting the rails," and were probably double flanged wooden wheels, but in 1734 wide single flanged cast-iron wheels were in use on a wooden

railway near Bath. The example shown, however, is a narrow single flanged cast iron wheel for running on metal rails, and is from the cast-iron edge-rail line connecting Belvoir Castle with the Grantham Canal, where it was in use from 1793 to 1903.

The wheel is now 22·75 in. diam. and 3·5 in wide on the tread, into which, however, a deep groove has been worn, partly owing to the very narrow face of the rails. It ran loose on the conical end of a fixed axle and was secured by a washer and split pin, the arms are curved so as to prevent fracture by cooling stresses after casting Inv. 1904–3

176. MANSELL'S RAILWAY WHEEL. Contributed by the Commissioners of the Great Exhibition of 1851.

This construction of railway wheel, introduced in 1848 by Mr R. C Mansell, is now almost universally used for passenger carriages The wheel consists of a rolled tire and a metal boss, but instead of spokes the wheel is made up of solid sections of hard wood with the grain arranged radially At the centre the wood is held between flanges, and at the rim between two rings bolted together by through bolts The tires are rolled with a groove on each side, and the rings have corresponding ridges formed on them, and in this way the tire is secured to the rest of the wheel The great advantage of this method of attachment, which is also used for wheels with iron spokes, is that should the tire break, even in several places, the segments will still remain on the wheel, and thus the probability of derailment through a fractured tire is reduced The wooden portion of the wheel has an important action in reducing the noise and jolting of the wheel, as it gives a certain amount of elasticity, and even where iron arms are used a wooden packing near the tire is sometimes introduced The wooden sections are here shown dowelled together with metal plates, but the latter are now generally dispensed with Inv. 1860–46

177. RAILWAY WHEEL WITH BROKEN TIRE. Presented by R. Brotherhood, Esq., 1861.

This wheel, made by Mr Brotherhood, has a wrought iron boss, arms, and rim, with the usual flanged tire held continuously by securing rings as in No 176 This tire has broken, but the tire fastening has retained it in place although the wheel ran 115,000 miles after it had been fractured Inv 1861–53.

AXLE BOXES.

178. OIL AXLE-BOX. Contributed by D. Dietz, Esq., 1862.

This is a sectional example of an axle-box for railway carriages, patented by Mr Dietz in 1860 The lower front portion of the box forms an oil reservoir, which is closed at the back by a partition and a half-collar which is forced upward against the journal by a spring Any oil leaking past this partition collects on a saucer-shaped disc secured to the axle, and the edge of this disc is continuously wiped by a hinged finger which returns the oil on to the top of the bearing The inner end of the box is closed by a millboard disc to exclude dust. Inv 1862–19

179. ROLLER BEARING AXLE-BOXES. Lent by the Empire Roller Bearings Co., Ltd.

The use of rollers for the reduction of bearing friction has been known for centuries, but the modern application of the principle dates from the introduction of the ball-bearing in the bicycle, and subsequently for machinery where the loads are not great. For heavy loads, however, the limited surface of contact of a ball is insufficient so that cylindrical rollers are used, mounted in cages which keep them parallel and prevent cross-winding

One example shown is a railway carriage axle-box with a journal 4 in. diam.; in this there are eight rollers 1·75 in. diam and 8 in. long held in position by a gunmetal cage. The rollers run on the axle itself and on the cast iron casing surrounding them, no hardened races being provided The second example is an axle-box for a tramway car with a journal 2·5 in diam This has eight rollers 1 in. diam. and 6 in. long, similarly mounted.

These bearings greatly reduce the rolling friction especially when starting the vehicle. Inv. 1898–75 and 76.

BUFFERS.

180. BUFFER FOR ROLLING-STOCK. Contributed by Messrs. John Spencer & Sons, 1860.

This is a sectional example of a construction of spring buffer introduced by Messrs. Spencer and Mr. H. L. Corlett in 1854. The plunger is provided with a projecting collar at the back, which, by coming into contact with an internal projecting collar at the neck of the fixed casing, limits the forward travel. After the plunger has been placed in position the head is riveted to it; a volute spring is then inserted behind them in the casing and, while under compression, is fixed in position by a back cover secured by four interlocking lugs forming bayonet joints. Inv 1800-57.

181. RAILWAY BUFFER AND DRAWING. Lent by Messrs. Ibbotson Bros. & Co., 1891.

These show in section a modern buffer for absorbing the concussions of rolling stock. It consists of a solid steel head and plunger with a reduced tail, on which a flanged collar with an elliptical exterior can, by means of the special wrench shown, be screwed up solidly against the shoulder on the plunger. The plunger is carried in a casing bolted to the buffer beam, and encloses a volute spring under considerable compression The base of the casing is formed by an iron plate with a central hole, through which the tail of the plunger passes, and is so kept in line Messrs Ibbotson's locking nuts are employed on all the bolts shown. Inv 1891-144.

COUPLINGS.

182. MODEL OF LINK AND PIN COUPLING (Scale 1 : 8.) Lent by A. H. Higgins, Esq., 1900.

This form of coupler was, until 1880, almost universally used for goods wagons in America, where central buffers are generally employed Each buffer has a horizontal slot in its face, through which a long link is inserted and there secured by a vertical pin dropped in at the back of the buffer, the other end of this link is similarly secured by a pin behind the corresponding buffer In coupling, the shunter had to remove the pin by hand and replace it after the link had been inserted, the whole operation being both difficult and dangerous Inv 1900-11

183. MODEL OF AUTOMATIC COUPLING. (Scale 1 . 4) Presented by Louis Sterne, Esq, 1895.

The model shows a pair of buffers fitted with a form of coupling introduced by Mr Sterne about 1874 It is intended for vehicles with a single central buffer, and is so constructed that the contact of the buffer secures the coupling together of the two trucks without other assistance

The buffers are formed with a central cavity in which loosely fits a long link At the back is a vertical pin which, when dropped as low as it will go, is passing through the long link, so closing the coupling Before coupling together the link is pinned into one of the buffers, while the other buffer has its pin supported by a horizontal roller so arranged that the link, when entering, pushes the roller away and is itself secured by the falling pin When the pin is lifted for uncoupling, the roller, by gravity, returns to its supporting position Inv. 1895-59.

184. MODELS OF "JANNEY" COUPLINGS. (Scales 1 . 4 and 1 : 8.) Lent by the Rt. Hon. Sir F. J S. Hopwood, K.C.B., G.C.M.G., 1900.

In 1879 Mr Eli Janney, of Pittsburg, U.S A , patented a vertical plane car-coupler having a lateral moving knuckle , in 1887 the arrangement was accepted by the Master Car Builders' Association of America, with the result that the various modifications of the arrangement in use are classed as M.C.B couplers. It was then adopted as the American standard goods coupling, and its use has since been greatly extended to rolling-stock of all kinds.

The Janney coupling consists of a steel jaw fitted on one side with a knuckle or L-shaped lever turning on a vertical pin; this knuckle, when being swung inward, lifts a locking pin which subsequently drops and so prevents the return of the knuckle. An identical coupler is fitted to the end of the adjacent vehicle, and, so long as both or either of the knuckles are open when the vehicles come into contact, coupling will be effected; to uncouple, it is only necessary to raise either of the locking pins, by means of a chain or lever at the side of the vehicle. The knuckles have each a hole in them to permit of the use of the old link and pin coupler, when such a fitting is met with. At first this coupling gave some trouble through the locking pins occasionally creeping upward, but in the larger model, which represents the later form, there is an automatic locking pawl that prevents this motion; owing, however, to the pawl being attached to the lifting shackle, it in no way interferes with the pin being raised when disconnecting

Inv. 1900–10.

185. COMBINATION AUTOMATIC COUPLING. (Scale 1 : 4.) Presented by T. Wharton Ford, Esq., 1911

This represents the coupling arrangement patented by Mr W S. Laycock in 1889, it is intended for use during the transition stage, when automatic couplers are being introduced, and during which it is necessary that vehicles so fitted should couple up with others fitted with ordinary screw or chain couplings

The automatic coupler is of the M C B type, but, instead of being made in one with the draw-bar, it is made separate, and is pinned to the hooked end of the draw-bar so that it can swing downwards when not required, leaving the hook free for use with the ordinary couplings When in use the coupler is held up by a pin passing through it and resting in the opening of the hook

In the coupler shown the knuckle is locked by a vertically moving pin held down by a spring; it is unlocked from the side of the vehicle by a pull on a chain attached to the bellcrank lever that pushes up the pin from below, the knuckle being forced open by the same spring, so that it is always ready for recoupling without having to be opened by hand. Inv 1911–11.

RAILWAY BRAKES.

186. MODEL OF A CONTINUOUS BRAKE. (Scales 1 . 4 and 1 8) Presented by James Newall, Esq., 1862

This is an early form of continuous brake, patented by Mr. Newall in 1852 and 1857 Each vehicle of the train is provided with a brake gear, and also with a powerful helical steel spring by which the brake is applied Running through the length of the train is a shaft connected between the carriages by universal joints, and this shaft can be rotated by a hand wheel fixed in the guard's van, and which, by gearing, winds off the brakes, and compresses the helical springs throughout the train The brake is held off by a ratchet in the guard's van, where also is a clutch by which the gearing can be released and so the springs be allowed to act A flexible cord runs the length of the train so that the brake can also be at once applied by the engine driver While this brake embodies some features of modern appliances, it could never have been sufficiently powerful for the requirements of the present day Inv. 1862–108.

187. MODEL OF THE WESTINGHOUSE BRAKE. (Scale 1 : 4.) Made by the Westinghouse Brake Co., 1886

The Westinghouse continuous automatic pressure brake is a brake that is applied to all the wheels throughout the train, and which, when through any accident the train is broken or the apparatus deranged, is automatically applied. The power by which this is effected is fluid pressure, the medium being compressed air stored at a pressure of 75 lb per sq in above that of the atmosphere The system was patented by Mr. George Westinghouse in 1870

The Westinghouse is the form of continuous brake most extensively adopted, and in a train so fitted the engine is provided with a vertical direct-acting air-pump driven by steam from the engine boiler. The air so compressed, after passing through a regulator valve under the control of the driver, enters a pipe which is continuous throughout the train, the connection between the carriages being made by flexible hose, with an interchangeable and readily made union,

To the engine and beneath each carriage an air reservoir is fitted, and also a cylinder containing a single-acting piston, the piston rod of which is connected with the brake levers of each vehicle. The return stroke of this piston is caused by the action of a helical spring, which thus pulls the brakes off. Each air reservoir is fitted with a box containing a triple valve, which, when the pressure in the train pipe is reduced, opens a connection between the air reservoir and the brake cylinder, so that the compressed air can force out the pistons and so apply the brakes If, therefore, a train should be divided through the failure of a draw-bar or like accident, the air in the train pipe escapes, and the resulting fall in pressure at once applies the brakes throughout both portions of the train. On the engine and also on each guard's van is fitted a valve by which the air pressure in the train pipe may be lowered and so the brake be applied as required. These valves are so constructed that the application of the brakes may be rapid and powerful or only moderate, as the circumstances may demand Gauges are fitted both on the engine and in the guards' vans by which the pressure of air in the apparatus may be observed. After a stop has been made the brakes remain on until the engine-driver, by his large store of compressed air, restores the train pipe at once to full pressure

The model shows a four-wheeled carriage frame fitted with the Westinghouse brake The arrangement of brake levers is such that the four brake blocks to each pair of wheels are simultaneously applied, and with equal pressure, by the outward movement of the brake pistons The brake reservoir and its triple valve are arranged near the side of the framing, and the engine reservoir with a hand air-pump are attached to the table on which the model is carried, and the driver's regulating valve on the right-hand side By the length of flexible tubing introduced, the model can run on the metals, and the brake be worked experimentally

The large adjacent wall diagram shows the arrangement of the air pump, the driver's and the triple valve, together with the general arrangement of the brake cylinders and reservoirs. Inv 1886–83, and 1890–160

188. WESTINGHOUSE BRAKE GEAR IN SECTION. Made by the Westinghouse Brake Co., 1888.

This is a full-size example of the improved Westinghouse brake cylinder and reservoir, with the mechanism shown in section It differs from the earlier pattern in that the reservoir is combined with the cylinder, so forming a more compact arrangement The cylinder is at one end of the reservoir and the triple valve at the other The air passed from the reservoir by the triple valve to the brake cylinder is conveyed by steel tubing running the length of the reservoir Inv 1888–270

189. MODEL OF AUTOMATIC VACUUM BRAKE. (Scale 1 : 4.) Lent by the Midland Railway Co., 1897.

This shows a carriage underframe, with wheels, axle-boxes, etc , complete, fitted with the automatic vacuum continuous brake, in which there is a train pipe, with flexible connections and simple couplings, which communicates with the brake cylinder of each coach and is exhausted by a steam-jet apparatus on the engine. So long as the pressure in the pipes is below that of the atmosphere, the brake blocks remain off , but if, through the breakage of a pipe or the opening of a valve by a guard or driver, atmospheric air is allowed to enter, the whole of the brakes are applied with an effective pressure of about 12 lb. per sq in

The brake cylinder, shown in section, is arranged vertically, and to save the height occupied by a connecting rod is carried in trunnions as an oscillating cylinder , the piston is packed by a rolling ring of india-rubber The upper face of the piston is open to the vacuum reservoir, while both faces are, by a valve-box, placed in communication with the train pipe. The valve-box, however, contains a small ball valve which, on a sudden inrush of air, closes the entrance to the vacuum chamber, but permits the air to enter the space beneath the piston and so apply the brake. For shunting purposes a light wire is fitted by which the brake can be released from either side of the carriage. Inv. 1897–67.

190. DRAWINGS OF RAPID-ACTING VACUUM BRAKE. (Scale 1 : 4.) Presented by the Consolidated Brake and Engineering Co., Ltd.

These show an improved vacuum brake fitted with rapid-acting valves by means of which the braking is rendered as nearly simultaneous as possible on

each vehicle throughout the train, thus obviating buffing strains or bunching up of vehicles with resulting damage to rolling stock and discomfort to passengers. The arrangement embodies improvements patented by Mr. E. S. Luard and the Donors between 1904 and 1915.

When applying the ordinary vacuum brake, all the air is admitted to the train pipe through the driver's valve, and on a long train an appreciable time elapses before the brakes are applied to the last vehicle. With the improved arrangement, however, each vehicle is fitted with a rapid-acting valve on the train pipe, operated by the increase of pressure coming from the engine or from the carriage in front, which admits additional air directly

The drawings show the brake apparatus for engine, tender and carriages, both in the " brake off " and " brake on " positions The engine and tender have cast-iron brake cylinders and a separate vacuum reservoir of large capacity, while the carriages have a combined cylinder and reservoir, the latter being a solid drawn steel casing surrounding the cylinder and having the trunnions attached to it The ball valve is fitted to the piston, instead of to the cylinder cover as in earlier practice, and is provided with an extra rubber valve which stops any leakage past the ball valve When the train pipe is exhausted, by means of the ejector on the engine, the air in the reservoir and upper part of the cylinder is drawn out past the ball and rubber valves When, however, air is admitted to the train pipe, the valves close and the air pressure, acting on the underside of the piston, raises it against the partial vacuum above, and so applies the brakes As the piston rises, the reservoir space diminishes and the pressure in it increases, so that the effective braking pressure decreases also, this effect can be minimised by providing as large a reservoir as possible On the engine and tender the vacuum on the reservoir side of the pistons can be maintained, when the brake is applied, by a separate connection with the ejector

The rapid-acting valve consists of a rubber-seated disc valve attached to a flexible diaphragm forming the bottom of a small vacuum chamber which is exhausted at the same time as the train pipe through a small groove along the valve spindle The valve is normally held on its seat by an adjustable spring, but an increase of pressure in the train pipe opens the valve and admits more air at that point After opening, the valve closes again as the air leaks into the vacuum chamber The increase of pressure at one valve is rapidly transmitted to the next carriage and so on throughout the train, so that on a train of 60 vehicles, 1,800 ft in length, an ordinary service application takes 3 secs to fully set the brakes, as compared with 30 secs when the rapid-acting valves are not in use The rapid-acting valve can be put out of action by holding down the automatic non-return valve placed in the inlet pipe In the guard's van is an emergency valve which operates in the same way as the rapid-acting valves and may also be opened by hand

191. COMBINATION EJECTOR. Lent by the Vacuum Brake Co., Ltd., 1908.

This is a sectioned specimen of the standard type of combination ejector for the automatic vacuum brake, patented by Mr J Gresham in 1878–81.

A single fitting combines within it two ejectors, with their valves, and the air valve for applying the brakes There is a large ejector for rapidly exhausting the air from the train pipe when removing the brakes, and a small one, placed on its axis and at the rear part of it, for maintaining the vacuum against leakage when running, these communicate with the train pipe and are fitted with non-return valves Steam enters through a pipe at the top of the casing and the train pipe is attached to a flange below The small ejector is continually supplied with steam through a screw-adjusted valve, but its air supply is cut off when the brakes are applied The large ejector has its steam supply controlled by a disc valve, working on a horizontal axis, to the end of which is attached a handle, the enlarged boss of which serves as a disc valve which admits air to the train pipe when the brakes are to be applied, this valve is hollow and works against a flat face on the casing, while the air is admitted through perforations in its back. There are three positions for the handle; first, the mid or " running position," when the steam to the large ejector is cut off, the air valve is closed and the small ejector is working to maintain the vacuum, second, the rear or " brake on " position, when both ejectors are cut off and the air valve destroys the vacuum in the train pipe, thus applying the brakes; and third, the forward or " brake off " position, when the air valve is closed and both ejectors are in action for rapidly removing the brakes. The brake power may be varied by placing the

air valve handle in intermediate positions. The fitting is bolted by a flange to the back plate of the locomotive fire-box and an internal pipe conveys the exhaust steam and air to the smoke-box, where it acts as a blower. Drain pipes are fitted to carry off any water which may collect in the apparatus Inv. 1908–4

192. " DREADNOUGHT " VACUUM BRAKE EJECTOR. Lent by Messrs. Gresham & Craven, Ltd., 1922.

This is a sectioned example of the improved combination ejector for the vacuum brake, patented by Messrs H. E Gresham and G. Kiernan between 1903 and 1908 A single fitting comprises within it two ejectors with their steam valves and back-pressure valves, as well as the air admission valves for controlling the brakes

The small ejector is placed above and parallel with the large one and is continually in action to maintain the vacuum in the train pipe when running. The large ejector is brought into action for rapidly exhausting the train pipe when removing the brakes Both ejector nozzles are of the annular type, but the large one has a supplementary central jet also, they discharge into the same pipe which passes through the boiler to the smoke-box and exhaust pipe Steam enters through a pipe at the top of the casing and the train pipe is connected at the bottom, while a separate pipe leads to the reservoir side of the brake cylinders on the engine and tender, two back-pressure valves in series are fitted between the ejectors and the train and engine pipes, and a ball drip valve to dispose of any condensed steam The small ejector is supplied with steam through a screwdown valve placed in a passage beside the nozzle, but the large ejector has its steam supply controlled by a flat-seated drop valve which is lifted by a lever on the air-valve spindle when the driver's handle is moved from the " running " to the " brake off " position

The air admission valve is a rotating disc, with openings through it, working on a ported face on the body of the ejector, the ports are opened when the handle is turned to the " brake on " position and air then enters through a perforated casing at the back of the disc valve A portion of the valve casing is partitioned off and in the " brake off " and " running " positions serves to put the train pipe in communication with the ejectors by way of the upper part of the engine pipe In the " brake on " position, however, this communication is cut off and the small ejector continues to exhaust the engine pipe so that the vacuum is maintained at its full value in the engine and tender cylinders and the maximum effective brake pressure is obtained therein On the back of the closed part of the disc-valve casing an auxiliary valve is mounted which admits a small quantity of air so as to permit a more gradual application of the brake, this valve is operated by a lever attached to the driver's handle A relief valve is fitted to the space between the back-pressure valves and this can be set for any desired vacuum, below it is a ball valve which allows air to leak into this space when the ejectors are not working

The small ejector is 20 mm (0·79 in) diam and the large one 30 mm (1·18 in) diam, these being the most suitable sizes for use with a 2 in train pipe The ejector will work with pressures from 90 lb per sq in upwards and does not require fine regulation of the steam It is claimed to be much more efficient than the earlier types and to show a saving of 50 per cent in steam consumption Inv 1922–677

193. DRAWING OF VACUUM BRAKE EJECTOR. (Scale 1 : 2.) Presented by Messrs. Davies & Metcalfe, Ltd., 1921.

This shows a combination ejector and controls for the vacuum brake, patented by Messrs J J C and R D Metcalfe in 1909 and 1912 A single fitting comprises within it two ejectors with their steam valves, the air valve, and a valve for the steam brake on the engine, while one handle completely controls the action of the brakes It is constructed so as to be easily taken to pieces and kept in repair

The small ejector is continually in action and maintains the vacuum in the train pipe when running, while the large ejector is brought into action for rapidly exhausting the train pipe when removing the brakes Both ejectors are of the solid-jet type, the small one being placed above the large one and both discharging into the same pipe which passes right through the boiler to the smoke-box. Steam enters through a pipe at the top of the casing, and the train pipe is connected by a union at the bottom. The small ejector is supplied with steam through a screw-down valve seated on the back of the nozzle The large ejector has its steam supply controlled by a flat-seated drop valve which is operated by a cam below it and is only moved when the driver's handle is in the " brake off " position

The air admission valve is also of the drop type and is opened by another cam when the driver's handle is moved to the " brake on " position, air being admitted through perforations in the upper part of the casing. In the " running " position the small ejector alone is in operation

Two air back-pressure valves, one above the other, are fitted at the entrance to the train pipe, the small ejector drawing air through the lower valve only, while the large ejector draws through both The ejector is fitted with a relief valve which can be set for any desired vacuum When the engine is fitted with a steam brake, the valve for this is combined with the ejector, and is so arranged that it is automatically brought into action by the reduction of the vacuum in the train pipe. It may also be kept out of action or worked separately by hand.

The ejector will, under ordinary conditions, create a vacuum of 26 in. to 27 in. The small ejector uses 4 lb. of steam per minute and the large one uses 30 lb per minute

Inv 1921–153.

APPENDIX.

15a. DRAWING OF GEORGE STEPHENSON'S LOCOMOTIVE, 1815. (Scale 1 : 14.) Received 1923.

This is a contemporary drawing showing George Stephenson's second Killingworth locomotive in its later form, in which a chain replaced the original cranks and rods for coupling the axles The drawing was given to William Howe by George Stephenson, and is the earliest known drawing of this engine.
Inv 1923–545

25a. DRAWING OF THE "ROCKET" LOCOMOTIVE. (Scale 1 : 12.) Lent by the London Midland and Scottish Railway Co., 1923.

This drawing is believed to be that made for the Directors of the Liverpool and Manchester Railway, in 1836, when the "Rocket" was sold It shows the engine as it was at that date with lowered cylinders, improved smoke-box and a fire-box which is probably of the original form A complete tender of the period is also shown.
Inv 1923–569

59a. MODEL OF PASSENGER LOCOMOTIVE, 1840. (Scale about 1 : 5) Presented by Miss Boydell Houghton, 1920.

This is the underframe of a model locomotive which, although not strictly to scale, represents generally the standard inside-cylinder six-wheeled passenger engine of about 1840, the boiler has been removed so that the working parts may be seen The model was given to Mr S Tredwell, a railway contractor, by Victor Emmanuel II, King of Sardinia, about 1858

The model appears to follow the Stephenson practice and the outer framing resembles that introduced in the "North Star" built for the Great Western Railway in 1837 The cylinders were 15 in diameter by 20 in stroke and the driving wheels were 81 in diameter, giving a tractive factor of 55·56 The leading and trailing wheels were 42 in diameter and the wheel base was 10·83 ft The smoke-box completely enclosed the cylinders and was supported with them by brackets bolted to the outer frames The valve chests were on top of the cylinders and the valves were driven, through rocking shafts and levers, by four eccentrics fixed on the middle of the driving axle There was a forward and a backward eccentric for each cylinder, and each eccentric rod ended in a notch or gab provided with spreading jaws forming a fork; the gab ends of the rods faced downwards and were suspended by links from levers on two countershafts so connected together that, when the reversing lever was moved, one gab of each pair was lowered into engagement with a pin on the valve lever, while the other was lifted out of gear The addition of the forks to the gabs, made about 1837, enabled an engine to be reversed without the aid of hand levers on the footplate as were required in the earlier gab gears

The outside frames were of wood, flitched on both sides with iron plates which were formed in one with the axle-box horns These were trussed with round iron rods and tied together by the buffer beams and by the boiler supports All the springs were placed above the axles but those for the leading and trailing wheels were beneath the frames between the horn-plates In addition to the outside frames there were four wrought-iron longitudinal inner frames extending between the fire-box and cylinders, to which they were secured by bolted brackets Each of these frames carried a pair of guide bars for the crossheads, and also provided an additional crankshaft bearing, which was provided with adjustable wedges The length of the main frames was 17·25 ft and the overall width was 7 ft
Inv 1920–425 S M 1693, 1694.

65a. DRAWING OF HAWTHORN LOCOMOTIVE, 1852. (Scale 1 : 12.) Presented by F. G. Hambleton, Esq., 1923

This shows a six-wheeled four-coupled inside cylinder engine built for the Oxford, Worcester and Wolverhampton Railway in 1852 The drawing was made by David Joy in 1858
Inv 1923–298

109a. MODEL OF ELECTRIC LOCOMOTIVE. (Scale 1 : 10.) Lent by Messrs. Brown, Boveri & Co., Ltd., 1923.

This represents a 4–6–2 type electric locomotive built for the Swiss Federal Railways. It is fitted with the form of individual axle drive patented by the makers in 1916–17 (*see* No 113) It operates with single phase current at 15,000 volts and is rated at 2,000 H P.
Inv 1923–572.

LIST OF DONORS AND CONTRIBUTORS.

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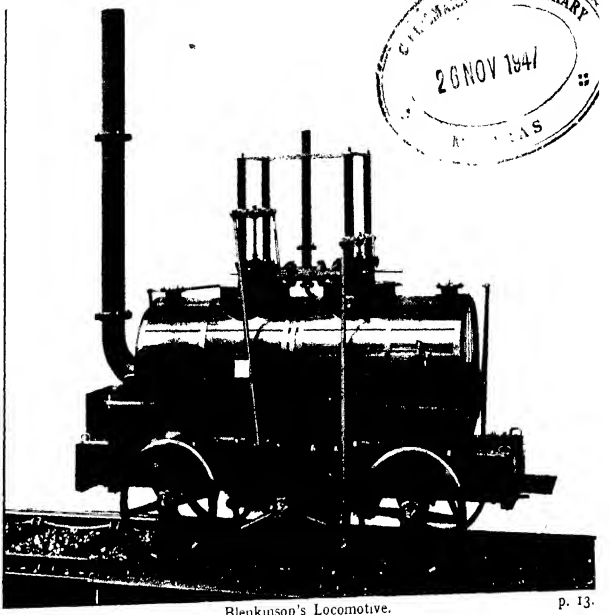

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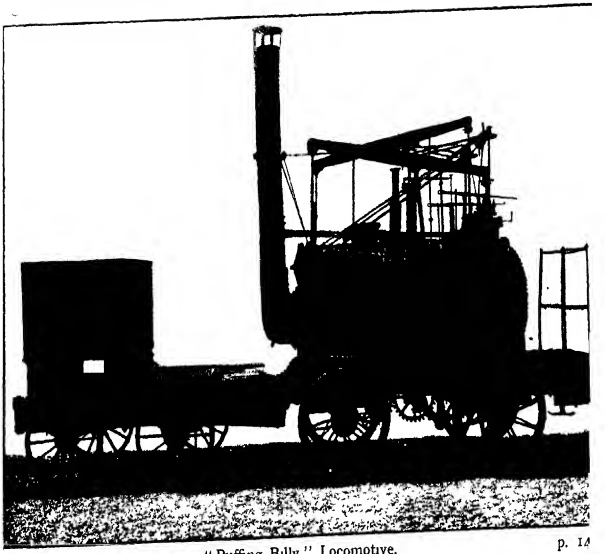

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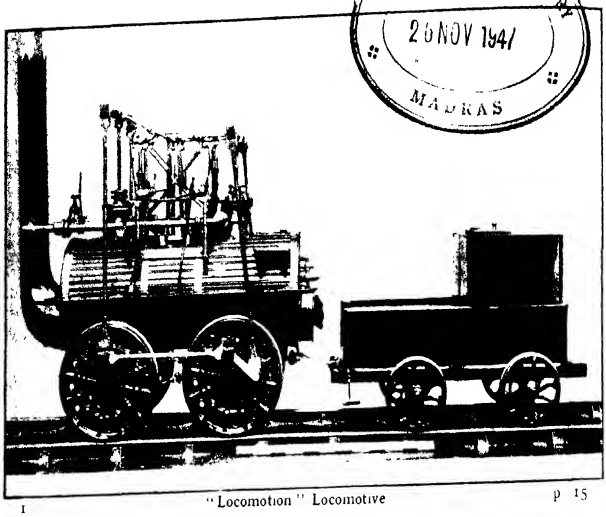

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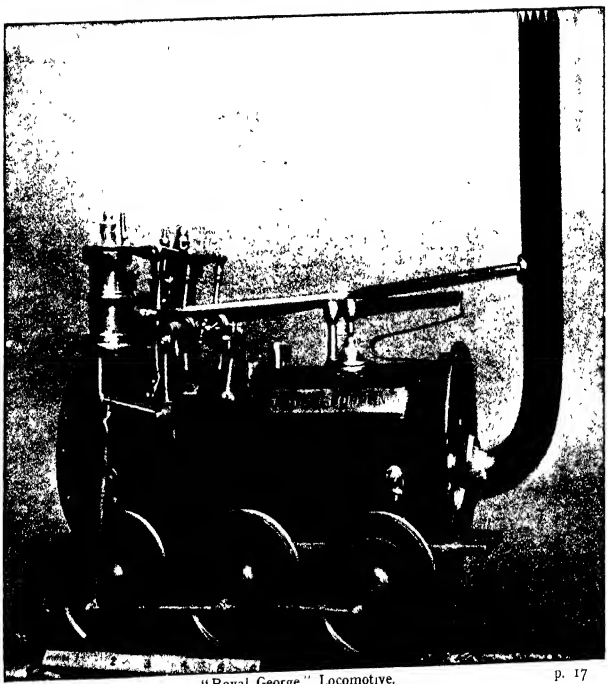

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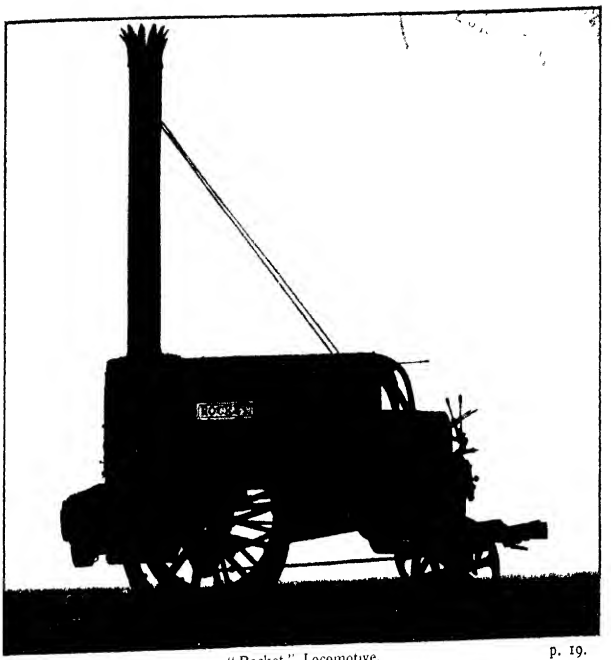

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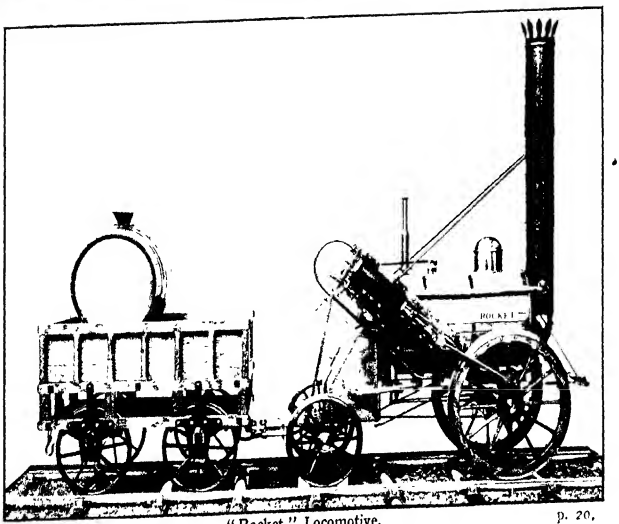

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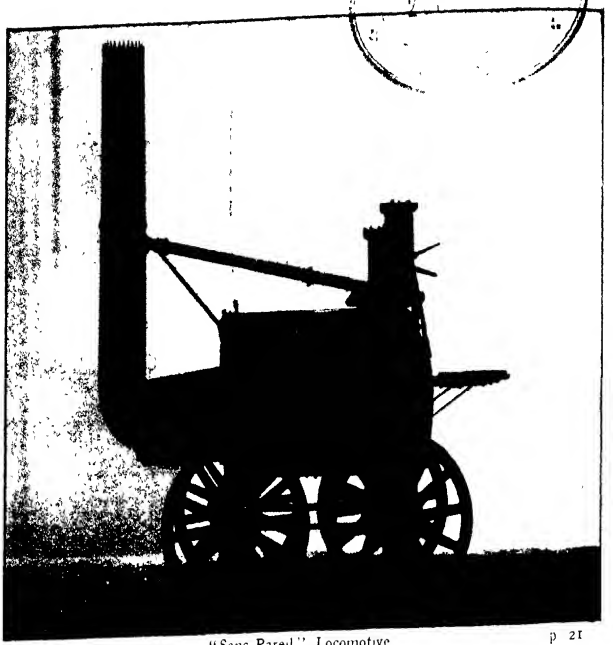

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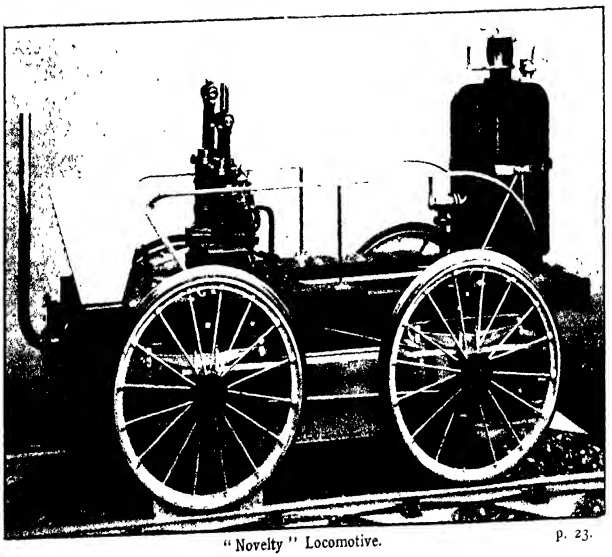

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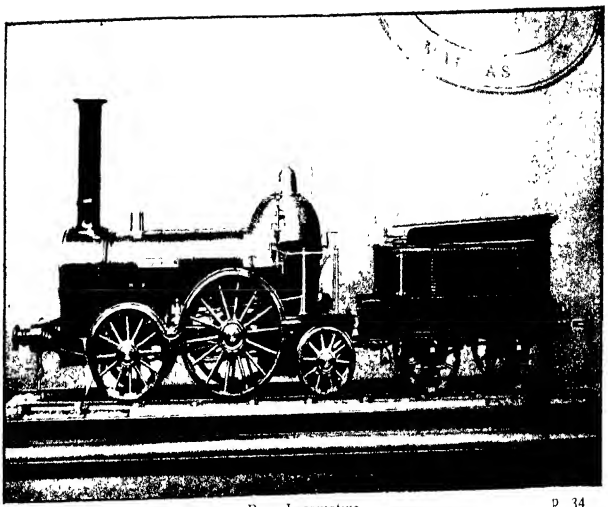

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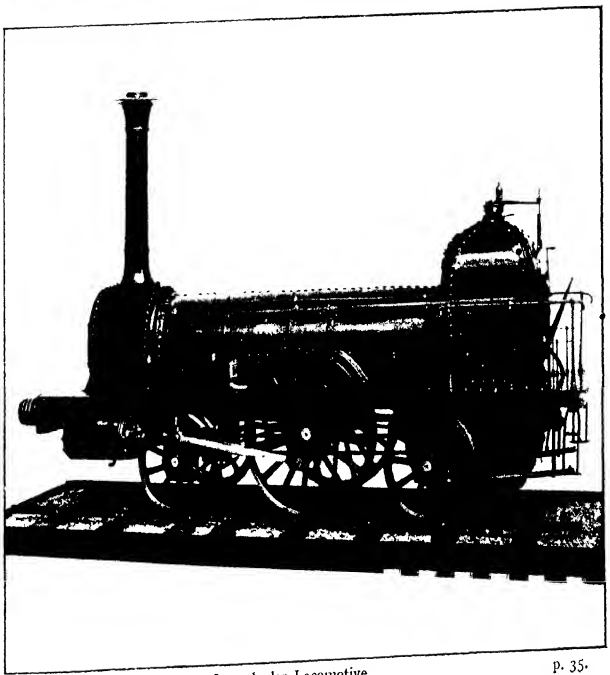

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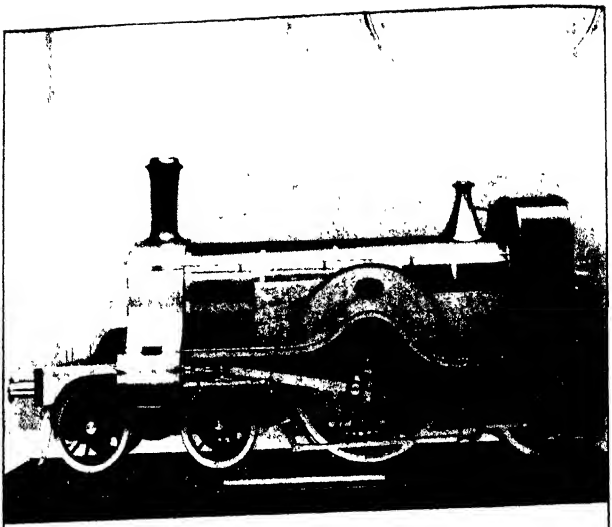

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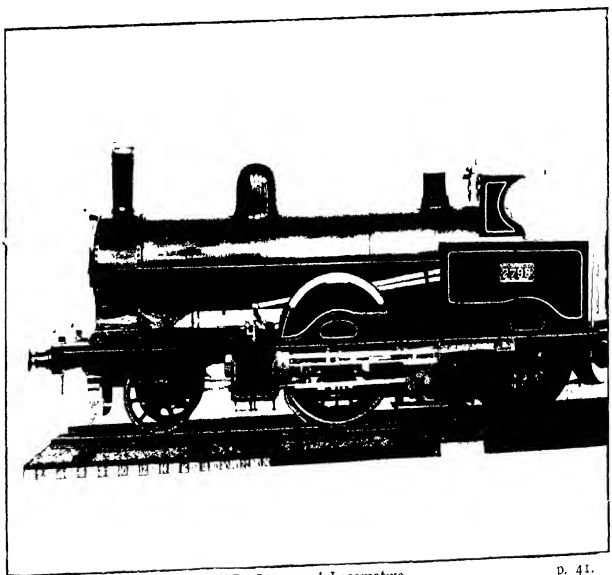

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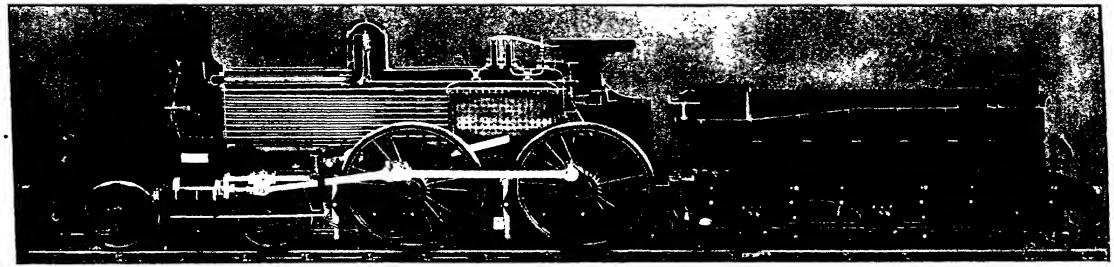

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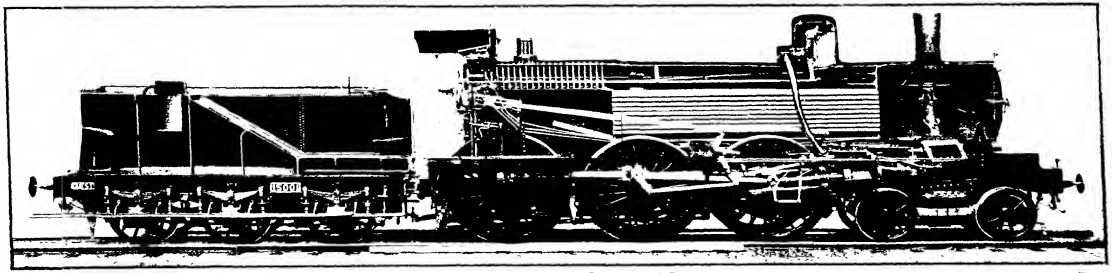

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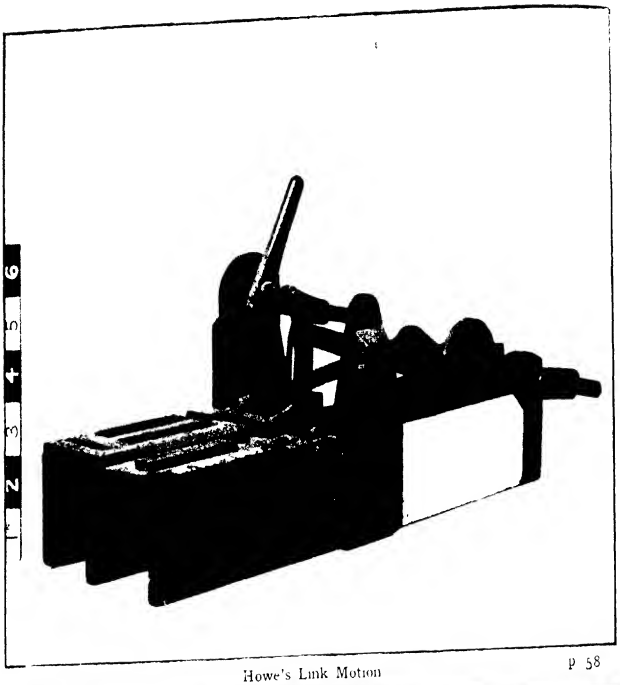

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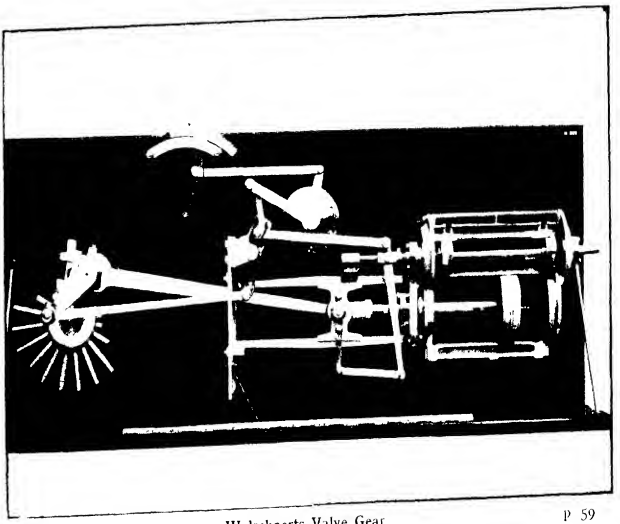

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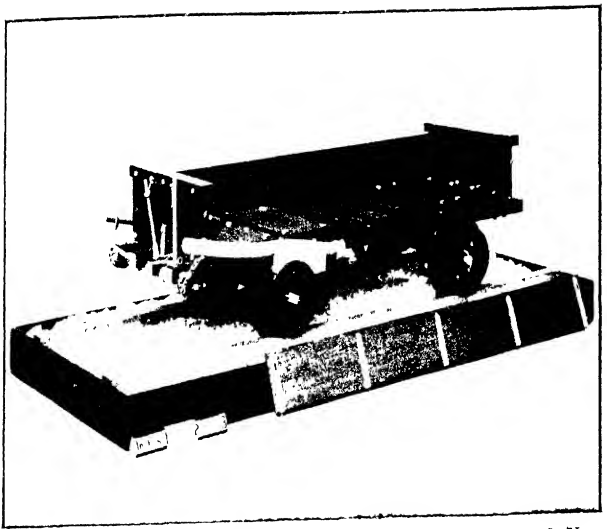

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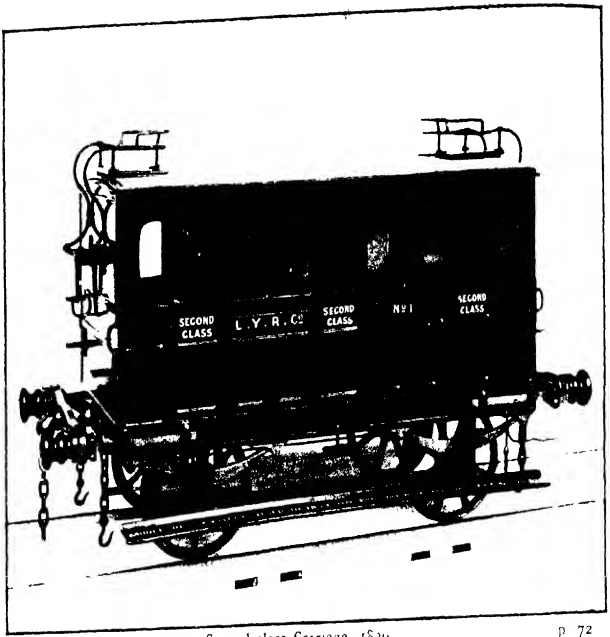

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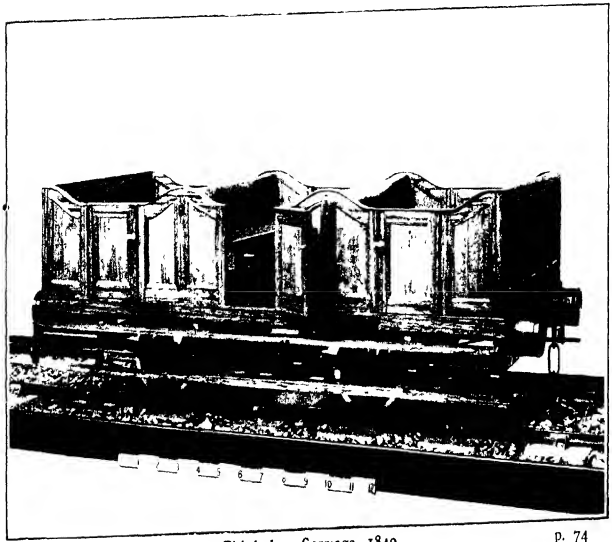

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BOARD OF EDUCATION

CATALOGUE OF THE COLLECTIONS IN THE SCIENCE MUSEUM

SOUTH KENSINGTON

WITH DESCRIPTIVE AND HISTORICAL NOTES AND ILLUSTRATIONS

WATER TRANSPORT

I. SAILING SHIPS

COMPILED BY

G. L. OVERTON, A.R.C.S.

1923

PRINTED AND PUBLISHED BY
HIS MAJESTY'S STATIONERY OFFICE, LONDON

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PREFACE

The Science Museum, with its Collections and Library, aims at affording illustration and exposition in the fields of mathematical, physical, and chemical science, as well as their applications to astronomy, geophysics, engineering, and to the arts and industries generally. To that end the Museum includes objects which are of historical interest as marking important stages in development, and others which are typical of the applications of science to current practice.

A Museum of Science was contemplated as an integral part of the Science and Art Department from its beginning in 1853, and in 1857 collections illustrating foods, animal products, examples of structures and building materials, and educational apparatus, were brought together and placed on exhibition.

The first of the Engineering Collections, that of Marine Construction, was formed in 1864, when the Royal School of Naval Architecture was established at South Kensington, and the ship models belonging to the Admiralty were transferred to the Museum from Somerset House, where they had previously been. This collection of ships of war was of great historical interest, and with the assistance of private donors and by purchase it was rapidly increased by the addition of many models of mercantile ships as well as of later ships of war, with the result that when the Admiralty removed their models to the Royal Naval College, Greenwich, in 1873, an important collection still remained at South Kensington. Engineering and Manufactures were first included in 1867, from which time the development of this portion of the Museum advanced steadily, but the transfer of the Museum of the Patent Office to the Department of Science and Art in 1883 added to the collection many machines of the highest interest in the history of invention and greatly increased its scope and value.

The collections of scientific instruments and apparatus were first formed in 1874, but it was only after 1876 that they became of importance. The Special Loan Collection of Scientific Apparatus which was held in that year in London brought together examples of all kinds from various countries, and a large number of these were acquired for the Museum.

In 1893, many Mining and Metallurgical objects were transferred to South Kensington from the Museum of Practical Geology in Jermyn Street, and these have subsequently been largely added to.

Mention should be made, too, of certain special Collections: The Watt Collection was presented to the Patent Museum in 1876 and contains original models made by James Watt; the Maudslay Collection, consisting of models of marine engines and machine tools, was purchased in 1900, and in 1903 a valuable collection of engine models, portraits, etc., was bequeathed by Bennet Woodcroft.

The Museum Collections are being continually increased by gifts and loans, and also by the purchase of such examples as are required to illustrate the application of science and the development of various types of instruments, machinery, etc.

(11155) Wt. P 1887/4092B/557 3,000 12/23 Harrow G.31

Notes.—A large number of objects in the Collections have been photographed. Selected prints from the negatives may be seen in guard books at the entrance stiles. Particulars of available prints and lantern slides may be obtained by personal application at the entrances or by letter addressed "The Director, The Science Museum, South Kensington, S.W.7."

A compressed air service furnishes the power for driving such of the machines as are shown in motion, and the service is available daily from 11 a.m. (Sundays 2.30 p.m.) till closing time. Where practicable, these objects are fitted with self-closing air valves, by means of which Visitors may start them at will. Other objects are arranged so that Visitors may work them by other means, and there are a few that can be shown in motion only by an Attendant.

CLASSIFICATION OF THE COLLECTIONS ILLUSTRATING WATER TRANSPORT.

Section	I.	Sailing Ships.
,,	II.	Mechanically-propelled Vessels.
,,	III.	Smaller Vessels (Boats, Yachts, etc.).
,,	IV.	Ship Design, Details of Construction, etc.
,,	V.	Marine Engines.
,,	VI.	Marine Boilers.
,,	VII.	Propellers.
,,	VIII	Marine Auxiliary Machinery.
,,	IX.	Harbours and Docks.
,,	X.	Rivers and Canals.

The models shown include representations of reed and log rafts, and a series of dug-outs with various modifications leading to the built-up type of construction. These include a simple dug-out (No. **4**), a dug-out strengthened by internal ribs (No. **5**), a dug-out with washboards or strakes of side planking added (No. **6**), and dug-outs to which both internal ribs and strakes of planking have been added (Nos. **7** and **8**).

There are also representations of skin boats. Though involving more ingenuity than other primitive types the skin boat did not develop beyond the small craft stage. In this country, as the coracle, it took the form of wicker-work covered with skins.

RAFTS.

1. WHOLE MODEL OF AMBATCH RAFT (SUDAN). (Scale 1 : 12.) Lent by W. H. Holloway, Esq

This primitive construction is used by natives on the Bahr el Jebel and White Nile, Sudan.

It is formed of logs of "ambatch" wood, roughly lashed together, and is very buoyant when the logs are in dry condition. To ensure dryness the raft is occasionally placed in a vertical position on the river bank It is propelled by poles or paddles, and can be carried by one man

The overall dimensions, obtained at Hillet Abbas, White Nile, are — Length, 8 5 ft , breadth, 4·5 ft Inv 1912–124

2. WHOLE MODEL OF PERUVIAN CANOE (Scale about 1 : 4.) Presented by F. W Bach, Esq.

This type of canoe is used for sea fishing off the Coast of Peru, and, as the fishermen sit astride it, it is known locally as a "caballito" (little horse)

It is built up of bundles of reeds or sedges and when the canoe becomes water logged, it is dragged on the shore and dried Inv 1920–622

3. WHOLE MODEL OF BRAZILIAN JANGADA (Scale 1 : 24.) Presented by W R. Birnie, Esq , 1893

This represents a species of raft used in many parts of the world and frequently styled a catamaran It is constructed of several logs of light wood, or even bamboo, pinned together, and is provided with seats and a mat-covered shelter amidship for protecting goods from the sun or spray A single mast is fitted and it carries a triangular sail secured to a light yard These rafts are steered by an oar at the after end, and are used for fishing even at a considerable distance from land. Inv 1893–214.

DUG-OUTS.

4. WHOLE MODEL OF KROO CANOE. (Liberia.) (Scale 1 : 12.) Lent by W. H. Holloway, Esq , 1908

This shows a typical native canoe as used for general purposes by the Kroo tribes along the Liberian coast

These craft are of simple dug-out character and vary in length from 18 ft. to 30 ft. They are propelled by two to four men, by means of a form of pronged paddle, peculiar to Kroomen, and may be successfully navigated in heavy sea or surf

The example shown was made from particulars obtained at Monrovia, Liberia, and represents a canoe of the following overall dimensions :—Length, 28 ft. ; breadth, 2·5 ft. ; depth, amidships, 1·75 ft Inv. 1908–73.

5. WHOLE MODEL OF RED SEA DHOW CANOE. (Scale 1 : 12.) Lent by W. H. Holloway, Esq., 1908.

This represents a form of canoe used as a tender to native dhows in the Red Sea.

These craft have considerable sheer and are of dug-out character, sometimes strengthened by the addition of internal ribs as shown in the model; they usually carry two men and are propelled by paddles.

Their maximum length is about 18 ft. The overall dimensions of the example shown, taken at Port Sudan, are:—Length, 15 ft.; breadth, 2 ft.; depth, amidships, 1·5 ft. Inv. 1908–76.

6. WHOLE MODEL OF CINGALESE OUTRIGGER CANOE. (Scale 1 : 16.) Presented by Count Watson-Höwen, 1881.

This type of vessel is largely used in the neighbourhood of Ceylon for fishing and similar purposes.

The main hull is of a hollowed tree-trunk, shaped externally to canoe form; above this are lashed washboards or side planking to give additional freeboard and accommodation. The characteristic feature of these craft, however, is an outrigged log of solid timber carried parallel to the hull upon two projecting transverse poles from one side, this adds considerably to the stability and also to the stiffness of the vessel under sail, and its effect is often increased by one or more of the crew sitting to the windward side upon the outrigger. The single mast, lashed to one of the outrigger poles, carries an unusually large fore-and-aft sail, and this, with the small hull resistance, makes very high speeds possible with a favourable wind The lengths of the craft vary from 20 ft. to 40 ft. Inv. 1881–45.

7. WHOLE MODEL OF SHILLUK CANOE. (Scale 1 : 12.) Lent by W. Herbert Holloway, Esq., 1913.

This illustrates the method of canoe construction adopted by the natives on the White Nile, Sudan. The particulars of the model were obtained at Hillet Abbas

Owing to the difficulty of obtaining timber large enough for making the simple dug-out type of canoe, the natives build up the sides of their vessel upon a dug-out foundation or keel-piece The few transverse frames are formed of bundles of wood wrapped in cloth and tied together, these frames likewise serve the purpose of butt-straps to the pieces of side planking As few tools and no nails are available, fibre-rope is used for lashing all the parts together. To prevent excessive leakage a layer of grass is placed between the plank-edges.

The anchor consists of a heavy block of wood, this, when thrown ashore, is sufficient to prevent drifting A single paddle, two poles and a bailing scoop are shown

Length, 30 ft, breadth, 3 ft. Inv 1913–134.

8. WHOLE MODEL OF LAGOS MARKET BOAT. (Scale 1 18) Lent by W H Holloway, Esq., 1907.

This native-made model represents one of the larger types of boats as used for ferry and general transport purposes upon the lagoons and coastal waters of Lagos, West Africa

It is an interesting example of the combination of "dug-out" with "built-up" boat construction The lower part of the hull is of a hollowed tree trunk, while the topsides are raised by strakes of planking, timber knees and floors, about 2 ft apart, give transverse strength to the structure.

These boats are propelled by sails or paddles—a larger steering paddle being worked from a platform at the stern

The carrying capabilities of these craft vary from one to four tons (weight) and the dimensions are —Length, overall, 48 ft, breadth, 7·5 ft Inv 1907–52.

SKIN BOATS.

9. WHOLE MODEL OF BIRCH-BARK CANOE. (Scale 1 : 8.)

This represents in general form and construction the canoes used by native Indians upon the lakes, rivers, and estuaries of North America. The chief characteristics of the type are shallow draught, considerable sheer and taper, similarity of bow and stern, absence of keel, and extremely light build.

The canoe is constructed of white birch-bark laid upon frames or ribs of white cedar. The latter are first placed in position and held together by flexible wooden

bands, then the outer shell, which has been carefully stripped in one piece from a suitable tree, is wrapped around them and secured by means of tarred thongs made from the roots of the cedar tree.

The boat is propelled by paddles, one of which is held by each rower who kneels or crouches upon the bottom of the boat while using it A small sail is occasionally used

The ordinary two-paddle canoe is from 16 to 18 feet long, and can be carried many miles by one man without great exertion, such canoes are also made large enough to carry as many as twelve men. Inv 1899-102

10. WHOLE MODEL OF GREENLAND CANOE. (Scale 1 : 8.) Lent by The Royal United Service Institution, 1903.

This represents the one-man " kayak " used by native Esquimaux for hunting and fishing

It consists of a light framework of wood or whalebone covered above and below with tanned seal-skins, sewn together with sinew-thread and made thoroughly tight The only opening is a central circular hatchway, admitting the boatman to his hips and into which he is secured by lacing the lower edge of his watertight jacket to the wooden coaming External protective bands of whalebone are added at the stem and stern, to prevent injury when grounding.

A double-bladed paddle is used for propulsion, and all apparatus and provisions are carried on deck, in racks or straps. A harpoon and lance for seal-hunting are shown, attached to the former is a skin bag or buoy which, when inflated, prevents the stricken seal from sinking

As these boats are very shallow and without ballast or external keels, they are easily capsized, so that long practice is necessary to successfully manage them in a heavy sea or surf, their extreme lightness, however, permits of their being easily carried, inverted, on the bearer's head

The usual dimensions are —Length, 16 to 20 ft., breadth, 1·5 to 2 ft., depth, ·75 to 1 ft , weight, 55 to 60 lb Inv 1903-90.

11. WHOLE MODEL OF IRISH CURRAGH. (Scale 1 · 8.) Lent by S. T. G. Evans, Esq., 1899.

This represents one of the small canvas canoes used for fishing and general purposes off the coast of Connemara and the Arran Islands The structure is very light and simple, consisting of a wooden frame for the top sides, into which the upper ends of the bentwood ribs are inserted Upon these transverse ribs longitudinal battens are lashed to serve as flooring, while the outer watertight covering is formed of well-stretched tarred canvas, the thwarts and seats, afterwards inserted, add somewhat to the strength There is no keel, and this peculiarity, combined with the great rise given to the bow, requires the exercise of considerable skill to keep the craft on its course if there is a head wind The canoe represented is propelled by two pairs of narrow-bladed oars, each oar working on a single thole pin which passes through a wooden block secured to the oar The approximate dimensions are – Length, 14·5 ft ; breadth, 4 ft , depth, 2 ft

The curraghs generally used have three thwarts, and are propelled by three men and three pairs of oars, when the wind is favourable a tanned lug sail is hoisted and the steering is done by the after oars. By the addition of ballast these somewhat crank canoes are made capable of standing bad weather, while the construction is so inexpensive that a boat to carry one ton costs only about £5 Inv 1899—103.

12. RIGGED MODEL OF NILE CARGO AND FERRY BOAT. (Scale 1 : 12.) Lent by W. H. Holloway, Esq., 1910.

This shows a vessel of somewhat primitive construction used in Nubia and the Sudan, and but seldom found below the First Cataract Particulars for the model were obtained at Korosko, some 100 miles above Assuan. Some of its structural features resemble those of the ancient Egyptian vessels (*see* No. **14**).

The boat has a large relative beam and a full midship body tapering gradually to the stern It is decked over the greater portion of its length and has a special beam amidships to give support to a single mast and lateen yard. The most noteworthy feature of the boat is the entire absence of internal

ribs or frames. Some structural compensation for them is obtained by the method of forming the shell: fairly thick and roughly-hewn planking is used, and the butts of each piece are scarfed to those of adjacent pieces so as to form a continuous strake. Each strake is fastened to that immediately below by nails driven at a slight inclination; their heads are housed in small external notches. Some degree of watertightness is obtained by caulking the seams with grass or moss; no paint is used upon these craft. A large built-up rudder with a tiller is used.

It is interesting to note that Herodotus, writing about 250 B.C., describes the Nile cargo boats of his day as being built without ribs and with the planking worked in short thick pieces held together by long bolts

Length, 25 ft; breadth, 9·5 ft Inv. 1910–79

EARLY SHIPS.

As far back as 3000 B C and even earlier there are records which show that the ancient Egyptians had attained considerable skill in the art of shipbuilding, and from the absence of a keel and of any internal ribs in their vessels as well as from the shape it is inferred that these vessels did not develop from the dug-out. It has been suggested that they were descendants of the reed raft, though the intervening stages of development are not known The Collections include a model of an Egyptian funerary boat of about 2000 B C which shows details of ship construction of the period and was made from particulars of an actual vessel unearthed in 1893. When designed to carry heavy loads, vessels of this type of construction were provided with a "hogging" truss as shown in the photograph representing Egyptian sea-going ships of the 5th Dynasty

The early Egyptian ships, like those of the later Phoenicians and Greeks were mainly propelled by oars, the sails that they carried being used under favourable circumstances only Vessels of this type developed into the galley which, with convicts or prisoners as rowers, remained as a naval factor in the Mediterranean until the introduction of steamships.

On the Mediterranean coasts considerable advances were made by the Phoenicians, who about 800 B.C constructed warships having two banks of oars About this time also the Greeks built their first warships, and in 350 B C. they possessed a navy and a complete dockyard equipment Their warships were provided with several banks of oars, to allow of quick evolutions in all weathers and to facilitate the use of the beak or ram with which each was provided. They were, however, small vessels making short voyages only; the hull length was 7·5 times the beam.

The Roman warships were about five times the beam in length and were known as "long" ships to distinguish them from their merchant vessels which were only about three beams in length and were known as "round" ships These merchantmen carried few oars, relying rather on sails, as they undertook oversea voyages; the carrying capacity was about 250 tons.

The early vessels of the Northern nations, such as the Viking ships, were of the "long" ship type, and in the 9th century King Alfred is said to have formed a fleet of similar vessels of an improved type for the protection of England against the Danes.

Information concerning the type of vessels then in use is given on various seals of the 13th century, and it appears that in Northern seas, outside the Mediterranean, the long or galley type of ship had then

given way to the sailing ship. With its greater accommodation for cargo, owing to absence of provision for the rowers, and a greater freeboard the sailing ship had marked advantages over the galley type of vessel, especially in the rougher seas outside the Mediterranean. Galleys were, however, used in England to a limited extent in later years and may be regarded as still represented by the State Barges employed on special occasions.

Auxiliary oars were at times, however, employed on sailing ships and the Museum Collections include a model of an 18th-century frigate (No. **56**) showing a series of oar ports for use when becalmed.

The English ships of the 13th century were single-masted vessels with temporary structures or "castles" at the bow and stern, and a fighting top on the mast head, the fighting being of the hand-to-hand order or at ranges at which arrows could be used. Steering was generally effected by a large oar at the side, but this was afterwards replaced by a rudder at the stern, an innovation dating back to about 1240. As the vessels increased in size three masts were employed instead of one, but the early fore and mizzen masts were very small. A square sail was employed on the mizzen until about 1400 when it gave way to the triangular lateen. Three-masted carracks were used at an earlier date in the Mediterranean than in the Northern Seas.

13. PHOTOGRAPH OF EGYPTIAN SHIPS (*circa* 2600 B.C.).

The bas-relief of which this a photograph, is the earliest record yet known giving a representation of sea-going vessels. The sculpture was discovered during the 1902–8 researches in the pyramid tomb of King Sahu-re at the northernmost of the three pyramids of Abusir, near Cairo. It belongs to the 5th Dynasty and therefore to a period estimated at about 2600 B.C.

Portions of four large vessels may be discerned whence an indication of the outlines of bow and stern and the general appearance of the sides may be obtained. The mast is a braced structure triangular in form and is here shown lowered into specially prepared crutches erected at the after end of the vessel. Paddles for propelling and for steering are also visible.

An interesting feature, portions of which appear on each of the vessels, is the bow-shaped "hogging truss" extending from end to end of the ship structure. It consists of a cable, secured at bow and stern, and kept in tension, vertical struts or crutches are placed at intervals along its length. Its purpose was to resist "hogging" or drooping at the extremities, a tendency to which long, shallow vessels especially of primitive construction are liable. This structural feature appears on Egyptian vessels of later date, *e.g.*, it is represented on all the ships forming the trading expedition to Punt (probably Somaliland) during the 18th dynasty (*circa* 1600 B.C.) and also on an obelisk-carrying vessel of unusual size of the same period, in the latter instance no less than six tension cables are shown in place of a single cable. The "hogging truss" is still to be found at the present day associated with modern construction in large shallow draught river steamers; examples are shown in P.S. "Empire," and the stern-wheel steamer "Inez Clarke," models of which are shown in other parts of the collections. Inv. 1914–386.

A drawing, showing one of the vessels separately, is also exhibited. Inv. 1923–508

14. MODEL OF EGYPTIAN FUNERARY BOAT (12th Dynasty). (Scale 1 : 10.)

This represents an Egyptian vessel used for the conveyance of the dead from the city of the deceased to the western shore of the valley. The model was copied from an actual boat, unearthed in 1893 from beside the northern pyramid of Dahshur, dating from the 12th Dynasty, probably about 2000 B.C. This boat is now preserved in the Cairo Museum (*see* adjacent photograph).

In general design it is of canoe form with easy lines, ample breadth and light draught. There are no transverse frames or ribs and no projecting keel;

further, the side planking is not worked in continuous strakes but is a patchwork of irregular-shaped pieces of roughly-hewn plank about 3 in. thick held together edgewise by wooden pegs, dowels and dovetailed ties. A scarcity of suitable timber might account for this method of forming the shell and also for the fact that most of the timber used in the construction of the funerary boat affords evidence of having been used previously for other purposes. Exact modelling of the planking throughout has not been attempted, but typical examples of the method followed are given. The topsides of the vessel are made up of several lengths with groove-and-tongue butts bound together by rope or leather lashings. A number of holes cut in the upper edges of these planks were used probably for rowlock-pins. Transverse strength is given to the structure by eleven thwarts or beams which pass right through the thick side planking and are secured in position by vertical pegs or dowels. The deck is made up of short longitudinal portions resting in rebates between every pair of beams, the edges of deck boards are connected by rectangular dowels and the ends are secured to the beams by circular pegs. The square holes in the deck boards were used for the stanchions supporting the canopy which was usually fitted to these boats Bronze fittings were sometimes used on vessels of this period, but few, if any, metal fastenings.

For working the two large steering paddles or rudders there are two upright posts at the after end, these were originally connected by a cross-bar at the top. Rudders and rudder-posts are elaborately painted and surmounted by symbolic hawk's head ornament

The colouring of the original boat has been reproduced on one side of the model. Many funerary boats were painted green amidships with yellow ends. The general finish of the model is superior to that of the original, which had an external coating of gypsum before painting.

The dimensions of the boat are —Length, 33·5 ft ; breadth, 7·5 ft. It is interesting to note that many features of this boat survive in the Dongolawi boats of the present day.

(*See* Reisner, Cat. Gen des Antiq. Egyptiennes, 1913, No. 4925)
Inv. 1915-59, S M. 658.

15. PHOTOGRAPH OF EGYPTIAN BOAT (*circa* 2000 B.C.).

This represents the model, in wood, of an Egyptian boat which was found in an ancient tomb at Assiut, Upper Egypt, and is now preserved in the Cairo Museum. It belongs to the 12th Dynasty, *i e*, to a period about 2000 B C

This model is about 5 ft in length and is one of the finest examples yet discovered of contemporary wood modelling Among the details to be seen in the photograph are —A well-built cabin with vestibule; a round, tapering mast with elaborate mast-step, the rudder-post aft, the projecting deck-beams ; and figures of the boat's crew

(*See* Reisner, "Cat Gen des Antiq Egyptiennes," 1913, No 4918)
Inv 1914-181.

16. PRINT OF A ROMAN WARSHIP Presented by T. Dyer Edwardes, Esq , 1868

This print represents a Roman grappling corvus, a type of vessel used in the Naval Battle of Mylae in 260 B C between the Romans commanded by Duilius and the Carthaginians

The " corvus " (Latin) or " korax " (Greek) takes its name from the boarding bridge which was " beak like " in design.

The hull was built of fir, secured with oak pegs or bronze nails, the seams were caulked with tow secured with wax, and the whole covered with tar or wax or a mixture of both.

She was rigged with a mast and squaresail and classed as a " bireme," *i e*., she was propelled with two banks of oars

The sail was taken in before going into action.

Rope girdles were fitted round the vessel usually resting on the top edge of a convenient horizontal wale to support the boat from the shock of ramming, etc

The oar ports were closed by a leather sleeve, the oar being secured to one end, while the other end was fixed to the edges of the port.

Grappling was effected by the machine shown in the bows consisting of a stump mast supporting a radial jib, from the end of which was secured a weighted grapnel, operated by a tackle at the lower end, and also by the boarding bridge with the beak on the outboard end for hooking on to the enemy's gunwale.
Inv. 1868-125.

17. RIGGED MODEL OF VIKING SHIP (A D. 900). (Scale 1 : 24.) Made in the Museum Workshop, 1913. Plate I, No. 1, p. 14.

This represents in general features a " long-ship," or war vessel, of moderate dimensions, as used by the Scandinavians during the 8th to 10th centuries.

The principal details of the model are taken from an actual Viking ship which was discovered in 1880, in a tumulus, at Gokstad, Norway, and which is now preserved at the University Museum, Christiania. Its general appearance is shown by three adjacent photographs. the gable-ended superstructure there seen is the burial chamber of the chieftain or owner of the vessel, indeed it is to the practice of this kind of burial that we owe the preservation of the vessel The chamber, not being an essential part of the ship, is not reproduced in the model. The bow and stern portions of the vessel have decayed away and a conjectural restoration of these parts has been attempted in the model. On the port side some of the outside planking and deck-boards have been omitted and a portion of the mast-chock has been cut away in order to show internal details of the structure

In general design, constructive detail, and workmanship, this vessel indicates a knowledge of shipbuilding much in advance of that shown by Northern maritime nations of several centuries later It is well proportioned, has easy entrance and run, a deep rockered keel and considerable sheer. It is lightly built of unpainted oak, and has a scarfed stem and stern posts, also beams, knees and frame timbers The main frames, 17 in number, consist of grown floors spaced about 3 ft apart and reaching on each side as high as the thwarts or beams. Transverse strength above these is obtained by vertical knees upon every beam and by short timbers extending downwards from the gunwale at alternate frame-stations Short pillars, ranged along the centre line of the ship, give further support to the beams A transverse bulkhead is fitted near the bow and another abreast of the rudder position aft The external planking, which varies from ·5 in to 1·5 in in thickness, is worked clincher fashion and is held together by iron rivets, the two thicker strakes carry the beam-ends and oar-ports respectively

The frame floors are not secured to the keel but are tied to the lower strakes of planking in a peculiar manner In trimming these strakes from thicker slabs a short " tabling," or raised portion, was left on the inner surface of each in the way of the transverse frames Holes were bored sidewise through this tabling in way of the frame and also through the adjacent portion of the frame itself, and then a cross-lashing of tree roots was used to bind the two together Iron spikes fastened the garboard strakes to the keel and also the plank-ends to the stem and stern posts Portable deck-boards are fitted between the beams

The vessel was propelled both by oars and a sail Circular oar-ports, 16 a side, were used and they were fitted with an ingenious arrangement of pivoted shutter to prevent the influx of water Models are shown of the two principal patterns of oars used A single mast, with square sail, was customary and it will be seen that the arrangements for supporting and working it are somewhat elaborate A tapering oak block, notched over four amidship frames and resting upon the keel, forms a mast-step. Rising from this, on the fore-side of the mast heel, is a short vertical post which gives support to a large parallel-sided mast partner or chock which also rests upon six consecutive beams The upper surface of this chock is shaped towards each end to a fish-tail form, and a slot is cut in the after part to facilitate the raising and lowering of the mast, a portable cover or slab is provided for this opening The two side-chocks, fitted between the frames at the deck level amidships, may have been used for sheer legs or windlass for lifting the mast

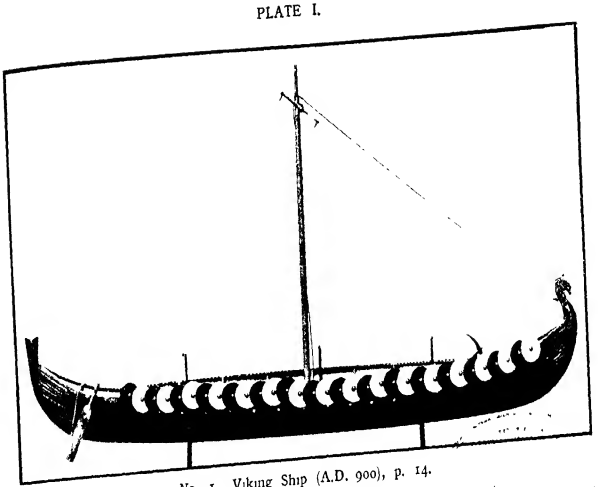
The three posts or stanchions of equal height, with thwartship crutches at their tops, probably carried ridge-poles for an awning to cover the whole of the vessel, while the cords for securing this passed through the small rectangular holes shown under the gunwale

Steering was performed by an oar-shaped rudder having a bearing upon a conical wood-chock on the starboard (*i e*, " steer-board ") side ; it was supported by ropes passing through the ship's side and was worked by a short tiller An iron anchor with wooden stock was used, but as only the stock of this has been preserved, the form of anchor here shown is conjectural A specially prepared landing-plank was carried in the vessel

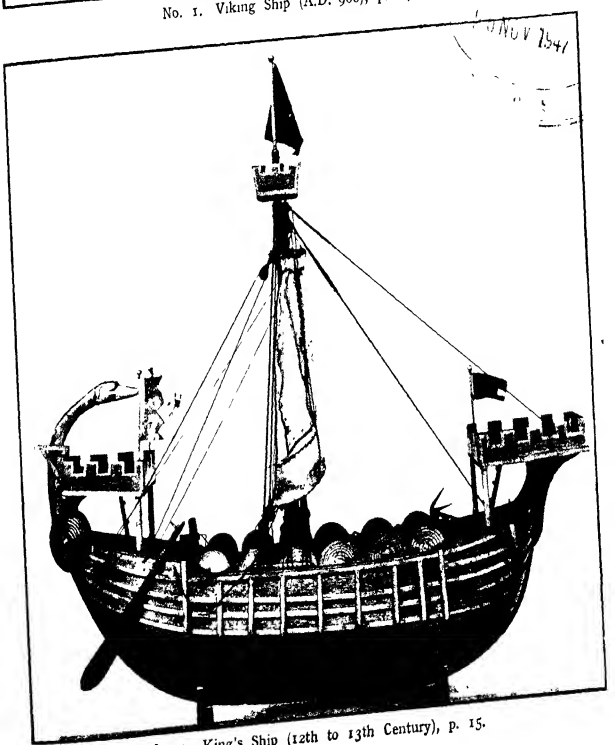
The complement of the vessel was about 70 men, the majority of whom carried, in action, circular wooden shields, which, when not in use, were stowed along the gunwales as shown.

Contemporary bead-ornament is reproduced upon the edges of keel, stem, stern plank-edges and gunwales ; a strapwork pattern is shown upon the oar

PLATE I.



No. 1. Viking Ship (A.D. 900), p. 14.



No. 2. King's Ship (12th to 13th Century), p. 15.

port shutters, and a concentric and intersecting circle ornament upon the deck-boards. The figure-head is copied from a design repeated upon various articles of furniture found in the Gokstad ship.

The approximate dimensions of the original vessel were:—Length, overall, 79 ft., breadth, extreme, 16·5 ft., weight, with fittings, 20 tons.

(*See* Nicolaysen, "The Viking Ship from Gokstad," 1882.)

Inv. 1913-198 and 1914-701, S.M. 507, 508.

18. RIGGED MODEL OF KING'S SHIP (12th to 13th century). (Scale 1 : 24) Presented by James Dixon, Esq., 1908. Plate I, No. 2, p. 14.

The term "King's Ship" appears to have been applied originally to the long-ships or war galleys of about 60 oars built by Alfred the Great in 875.

This model, made by Mr F. H. Mason, R.B.A., represents an English man-of-war of the Norman and early Plantagenet periods, such as may be seen on the 13th-century seals of some of the Cinque Ports. It has greater proportional beam and fuller lines than the contemporary warships of the oar-propelled galley type.

Oak was generally used in construction, the planking was worked flush and then caulked with moss, hair, and pitch, the sides were further strengthened and protected by external timbers and rubbing-pieces. Temporary structures or "castles" at the bow and stern, and smaller "top-castles" at the mast-head, were erected for the use of the fighting men. Decks and platforms were also of a portable character. Wooden shields were hung around the bulwarks for the better protection of the crew, the shields and banners of the knights were hung upon the castles. A single pole mast was used, spreading a large decorated square-sail, sail was taken in when necessary by detaching the "bonnet" or lower portion. Steering was effected by a large oar on the right-hand side. These vessels were decorated with heraldic carvings and painted in bright colours, red being a favourite colour. Their burden varied probably from 40 to 160 tons.

Inv. 1908-79, S.M. 21.

15th and 16th CENTURY SHIPS.

Considerable progress was made in overseas navigation during the 15th century. Previously navigation had in general been confined to the Mediterranean and other inland seas and the oceans were not regarded as navigable. Under the influence of Prince Henry the Navigator, the Portugese explored the west coast of Africa in the early part of the century. In 1486 Bartholemew Diaz reached the Cape of Good Hope, and in 1497 Vasco da Gama arrived at India by way of the Cape. A great problem of that time was to discover a sea-route to the East to replace the overland route employed for commerce. Christopher Columbus, in an attempt to reach Asia across the Atlantic made a voyage from Spain in 1492 and discovered the West Indies. This subsequently led to the discovery of the continent of America.

Columbus's ship, the "Santa Maria," is represented in the Collections by a model (No. **22**) and shows the high overhanging forecastle and the high poop of the period. These erections, which were developments of the temporary fighting castles of the earlier vessels, now formed part of the ship's structure, and in the 16th century they reached extreme properties "for majesty and terror of the enemy." The "Santa Maria" also shows the small topsail on the main mast and the spritsail under the bowsprit which came into use towards the end of the 15th century.

Up to the 16th century there were no fundamental differences between sailing ships used for fighting or for trade purposes. Special fittings were carried for the former but these could be easily removed or re-instated as required.

The introduction of cannon into land warfare, about 1350, was followed by their use at sea. The early guns were placed on the poop and forecastle and also broadside, over the gunwales. Gun ports between the decks were introduced about 1500, and finally led to a differentiation between merchant and war ships. Ships of the former class, which undertook oversea voyages, continued to be provided with guns and as late as the early part of the 19th century many merchant vessels carried an armament.

In the 16th century the larger warships were known as galleons and generally carried four masts, the fourth being named a bonaventure mizzen Gratings and nettings were carried at the waists as a protection against boarders, and the after bulkhead of the forecastle and the fore bulkhead of the sterncastle were provided with small guns known as "murthering pieces" for use in case an enemy boarded the waist At this time the ship's sides were made to slope inwards or to "tumble home," that is the breadth above was less than at the water line This made the vessel more seaworthy and strengthened the decks as gun platforms

Improvements in the English Navy were made by Henry VII, who built the "Regent" in 1489 and the "Sovereign" in 1495 The former, said to have been of 1,000 tons, was probably the largest vessel of her time She carried 225 small guns The famous "Great Harry" or "Henri Grâce à Dieu" (*see* No **24**) was built by Henry VIII in 1515 to replace the "Regent," which had been destroyed by fire during an engagement with the French in 1512, and in 1553 the "Great Harry" was accidentally burnt at Woolwich

At the time of the Spanish Armada (1588) the largest vessel in the English fleet was the "Triumph," of about 1,000 tons, which was built in 1561 The flagship of the English Admiral on that occasion, Lord Howard of Effingham, was the "Ark Royal" of 800 tons built in 1587 Of the 197 vessels which formed the English fleet only 34 belonged to the Royal Navy, the remainder being merchant vessels impressed or hired from private owners With the exception of a few galley and other oar-propelled vessels belonging to the Armada, both fleets consisted of sailing ships As illustrating the different naval development in the Mediterranean at this period it may be mentioned that at the Battle of Lepanto, fought in the Adriatic in 1571 between the Venetians with their allies and the Turks, the galley type of vessel was employed Merchant sailing ships of large size, known as "carracks" were, however, employed in the Mediterranean at this time, and Genoese carracks of 1,600 tons burden are recorded as having been built in the 16th century

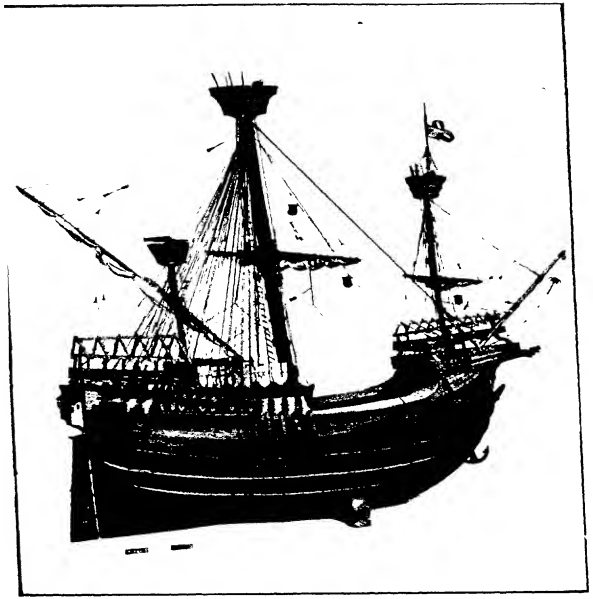
19. PRINT OF 15th-CENTURY SHIP. Presented by T. Dyer Edwardes, Esq., 1868

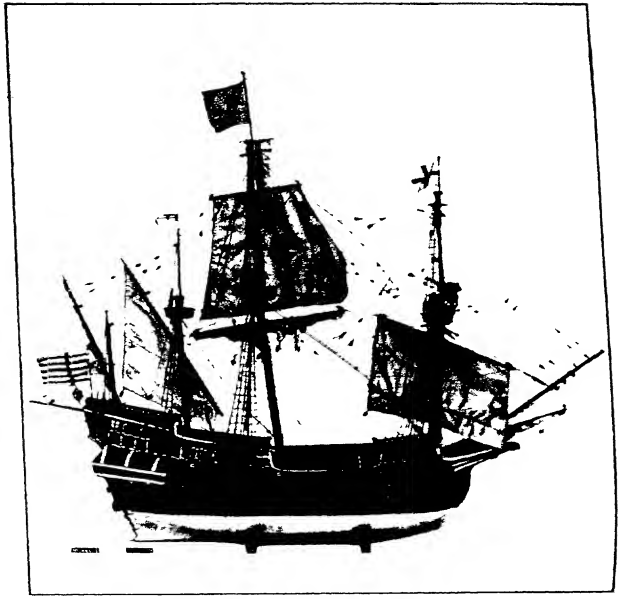
This print by Israhel van Meckenem of an illustration by "W A," a Flemish artist of the period, represents a vessel of the late 15th century There is no forecastle

The hull is protected by two horizontal wales on each side, and below the bottom wale rounded wooden chocks are shown which are probably fenders. Among other interesting details are circular ports, built up bulwarks, and hoops for spreading an awning or for drying nets

At the stern there is a "myke" or crutch to receive a lowered mast, which together with the presence of barrels, suggests that the print represents a fishing vessel, probably a "buss"

(*See* "The Mariner's Mirror," page 65, 1913.) Inv. 1868-136.





No 2 English Man-of-War 1580–1600, p. 21.

20. PRINT OF 15th-CENTURY SHIP. Presented by T. Dyer, Edwardes, Esq., 1868.

This print represents a "carrack" of the latter half of the 15th century. The hull is of the "round ship" type with wales and skids, and the forecastle overhangs to a considerable extent.

The ship is fitted with three masts and rigged with courses, while in addition, the main mast has a topsail yard. The rope fastened to the middle of the foot of the main course was known as a "bowge" The main yard is in two pieces lashed together and the details of the setting of the mainsail are apparently inaccurate. Inv. 1868-135.

21. RIGGED MODEL OF A FLEMISH CARRACK (1450–80). (Scale 1 : 60) Lent by R. Morton Nance, Esq., 1921. Plate II, No. 1, p. 17.

This shows a ship of the largest class known in Flanders at her time, every detail (with the exception of the long-boat and the deck-arrangements, that have been supplied from other contemporary sources) being copied from a contemporary print by the Flemish master "W A" The print, which bears evidence of being a portrait of some ex voto church model and is thus an excellent guide to the rig of the period, is so completely and carefully executed as to leave little or nothing of the original unrecorded, the perspective alone being at fault.

The hull, except that as that of a carrack it is a little deeper than usual, is typical of the 15th-century "round ship" The long, rounded stem is still like those of early northern ships but the full, round stern is more like the characteristically Dutch stern of the later "flight," "pink" and "hoy" Five wales defend the carvel-built hull longitudinally, and five skids vertically, on each side The skids are concentrated at the point where boats or heavy goods would be hoisted over the side by the tackles, the chainwales being here discontinued to allow such burdens a free passage Towards the stern, slung between two of the sliding shutters that give light and air to cabins, is the "steep-tub" in which salt meat was placed to soak in rain-water, and into which the cook's "shifter" got bodily, trampling the salt out of the victuals with bare feet or removing the day's ration with his flesh-fork This steep-tub was still found in the main-chains of 17th-century ships Besides an architectural arrangement of cabin lights, the stern shows two built out garderobes, between which is a stern-gallery, over the rudder-head The fore and after "castles" still by their light construction show that these were at the time regarded as fighting-stages rather than integral parts of the ship, the curved stanchions that support the highest decks not as yet being planked over The bulwarks of the "castles" are loopholed for arrows What later became the "half-deck," is here a pair of disconnected "corridors," each of which is defended by a mere fence, the "pavisade," upon which is hung a row of shields or pavises Seen through a hatchway in the deck beneath these "corridors" are the pumps and the capstan, the latter brought, by raising the deck abaft the main-mast, into line with the great hawses forward There are "corridors" again at the waist, but these have no "pavisades," and towards the bow run up to form a curved bulkhead These waist corridors were known also as "cowbridges," hence the name "cowbridge-head" given to this bulkhead and retained as the name of a bulkhead on later ships Under the arch of this "cowbridge-head" are seen the bitts, and scarcely visible, the "manger", a trough just below the hawses, in which water coming aboard with the cables or shipped when riding at an anchor was caught and allowed to return to the sea instead of flooding the decks The frames over the castles would in fight be covered with nettings, or, for pomp, with gaily-coloured awnings

In rig this carrack is still almost one-masted and single-sailed, the two other masts and sails being but small auxiliary novelties and the bowsprit as yet serving only to extend stays and bowlines and to support a chained grapnel, used, in boarding, to grapple an enemy ship so that the two vessels would swing together Although no maintopmast is shown, one might on occasion be carried, the contemporary topsail, however, was a very tiny thing, and, as we see on the foremast, the topmast was as much valued for use as a support for a netting, the round-tops being of some importance militarily, as we see by the supply of darts in the main and fore tops, the enormous galley-piercing dart of the fore-top, and the swivel gun of the mizzen-top, while a supply of stones for hurling down is suggested by the top-cranes with their "cranelines" and "cranelne-pokes" or bags.

The carrack was essentially a Mediterranean type, and although this one was drawn by a Fleming who calls it a *Knacck*, and is presumably itself Flemish, its rig is still characteristically Southern and galley-like Thus the many shrouds are without rathines and they are brought in and lashed round beneath the round-tops, the place of rathines being on the main-mast supplied by a " Jacob's ladder " abaft the mast —all galley features The main-stay still sets up with a single " heart " to the stem itself, as it is found in seals, etc , of earlier dates The forestay sets up in similar fashion to the bowsprit and already forms an attachment for the horses of the fore-bowlines, a foreshadowing of the later use of stays as attachments for running-rigging The form of the fore and main hfts is remarkable, those of the main yard being in appearance double, owing to the use of two separate blocks in preference to one double one The mizzen hft is in principle already like those used in 16th-century ships The " martnetts " of the mainsail are also like those of the 16th century Other noteworthy points are, the old lead of the main-bowlines, to the bowsprit, the crossed fore-braces, leading to the waist, and the lashing together of the tacks and sheets, all single ropes, at some distance from the clues. This latter, shown nowhere but in this print by " W.A," was apparently a part of the contemporary " harbour-trim " The mizzen-sheets are double and set up aft at the lean-to roofs of the garderobes no " outhcker " having as yet come into use All the deadeyes are heart shaped, as they remained during the 16th century , the blocks, however, are of a shape that, although it remained typical of galleys, became obsolete for ships within a century after the date of this carrack Another galley fashion is shown in the square mast head " calcet " of hardwood through which the ties run

Besides the swivel of the mizzen-top, eight guns are carried on carriages in the poop That this carrack, although for her time well armed, is primarily a ship of burden is, however, shown by the large cargo-ports aft , that on the larboard side being, as in the print, left open, and showing a cargo of wool-packs Such a carrack would be of about 800 tons burden and might be expected to cope with almost anything afloat at that time, both in fighting and in sailing qualities

Inv 1921-88, S M 1406

22. RIGGED MODEL OF S " SANTA MARIA " (Scale 1 20.) Presented by the Spanish Government, 1923. Plate III, p. 18

This represents the flagship of the squadron of three vessels commanded by Christopher Columbus during his famous voyage of 1492 which led to the discovery of America The expedition left Gomera (Canary Islands) on September 6th and landed on October 12th on an island of the Bahama group, which is now generally identified as Watling Island After exploring other islands in the neighbourhood, including Cuba, the " Santa Maria " on Christmas day of the same year, ran aground on a sandbank off the island now known as Hayti, and was abandoned

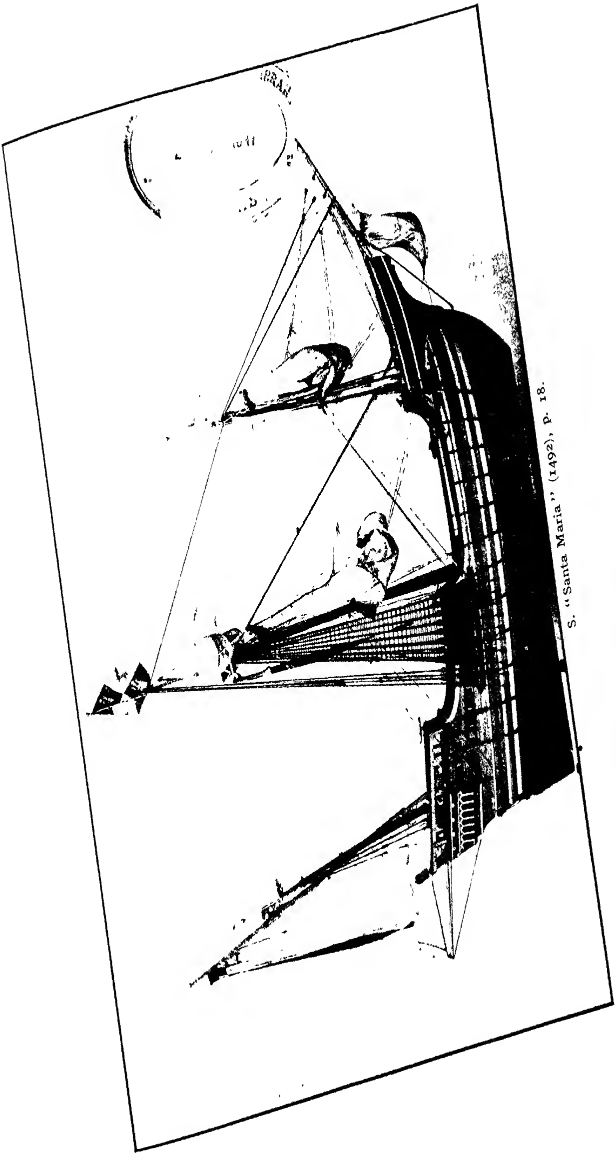
The model illustrates important features of ship construction of the period, and on the starboard side most of the planking has been omitted to show the frames The hull is carvel built with full lines, round bow, square stern, and on the sides it is strengthened externally by horizontal wales and vertical skids It shows the high poop and forecastle of the period, the latter overhanging the stem to a considerable extent There are three masts and a bowsprit The latter carries a square spritsail, and the foremast a square course On the pole main mast there is a square course and a topsail, the course being fitted with a bonnet and drabbler, two detachable portions used instead of modern reefs The correct position of attachment is indicated by the letters A M G P signifying " Ave Maria Gracia Plena " When furling, the main yard was lowered until it rested in crutches on the gunwales The mizzen mast has a lateen sail connected by a sheet with an outrigger projecting from the stern.

The flags and pennants represented include —on foremast, white flag with a green cross ; the badge of the Band of Discoverers , on the main mast at the truck the Royal Standard of Castille, quartered in white and red, with castles in gold, and red lions, and lower a red pennant with the full arms of Spain , at the mizzen truck, the Escutcheon of their Catholic Monarchs with the eagle of St John, and at the mizzen peak, the streamer of the Castille Armadas.

By the door to the Admiral's cabin on the starboard side of the poop there is a standard which was the emblem of the Royal powers conferred on Columbus and which he carried ashore when he took possession of the land he discovered

The dimensions of the vessel were —length between perpendiculars, 74 12 ft , extreme length of ship proper, 95 ft , length overall, 128·25 ft , breadth, extreme,

PLATE III.



S. "Santa Maria" (1492), p. 18.

25·71 ft , depth of hold, 12·46 ft , displacement, fully laden, 233 tons , weight of hull, 90·5 tons , burden, about 100 tons , complement, 52 men

Her armament consisted of eight pieces, two lombards firing stone shot weighing two pounds, and six falconets of wrought iron firing stones 13 ozs. in weight.

This model was built under the supervision of Captain Don Antonio de la Reyna y Pidal, Director of the Naval Museum at Madrid It was made from information obtained from documents, tide maps, various drawings and paintings found in different archives and churches, as well as from Columbus's diary The hull was constructed by Senor Valentin Zumalabe, the flags and miniature paintings were made by Senor Melchon Gaston y Moya, and the rigging, artillery and accessories were executed by the Warden of the Museum, Senor José Regueiro In 1892–3 a full-size reproduction of the vessel was constructed and a voyage was made across the Atlantic

The other vessels forming the small squadron were the caravels "Pinta" and "Niña" of about 50 and 40 tons burden respectively, each having a complement of 18 men During the return journey to Europe in 1493, Columbus was on board the "Niña," most of the crew of the wrecked "Santa Maria" being left at Hayti, or Española as that island was named by Columbus

Inv 1923–26, S M 1749, 1750, 1751

23. RIGGED MODEL OF MERCHANT SHIP (early 16th-century), (Scale 1 . 48.) Presented by James Dixon, Esq., 1908

This model, by Mr F H Mason, R B A , represents a type of ship developed, largely by the Genoese, Portuguese, and Spaniards, during the 14th and 15th centuries for the purposes of the sea-borne commerce

The most striking features of these vessels were —A low freeboard amidships, a high overhanging forecastle, and a heavy superstructure at the stern These erections, developed from the temporary fighting "castles" of earlier date, were now incorporated with the ship structure , they provided accommodation for the crew and afforded means of defence, although they increased the tendency to heavy rolling and pitching In war vessels of the 16th century these superstructures reached extreme proportions "for majesty and terror of the enemy"

The vessels usually carried from three to four pole masts , lateen sails were always used, but upper and lower square-sails were fitted to the fore and main masts in the later and larger examples A rudder, hung at the centre line of the stern, had, at this date, superseded the steering oar The ship's boats were carried in the waist when they could not be towed

The model represents a vessel of about 150 tons burden, but during the 16th century Genoese carracks of 1,000 tons burden are recorded as having been built

Inv 1908–77, S M 22

24. ENGRAVING OF "HENRI GRÂCE À DIEU" OR "GREAT HARRY" (1515).

This engraving, from a contemporary painting ascribed to Hans Holbein, is believed to represent one of the first vessels of considerable size belonging to the Royal Navy of England

Owing to the practice of giving the same name to successive ships of somewhat similar characteristics, it has been difficult to distinguish clearly between the "Great Harry" reputed to have been built by Henry VII about 1488–1503 and the "Great Harry" or "Henri Grâce à Dieu" of the following reign Authentic records, however, exist as to the building of this latter ship at Woolwich, in 1512–15, of her engagement with a French fleet off the Isle of Wight in 1545, and of her accidental destruction by fire at Woolwich in 1553. She carried four masts, each made in a single length without a separate top-mast and a long bowsprit , she was of about 1,000 tons burden, and had a crew of 700 men and an armament of 20 to 30 cannon with a large number of smaller guns

Various drawings of this vessel are in existence The adjacent prints of "Henri Grâce à Dieu" (No 26) from a drawing in the Pepysian Library, Cambridge, and "The Embarkation of Henry VIII" (No 25), show structures having abnormal proportion of height to length and breadth, which probably more nearly represent the actual type of ship in use at the beginning of the 16th century than does this engraving, which in some characteristics shows an advance towards vessels of the Elizabethan period Inv. 1905–162.

25. ENGRAVING OF THE EMBARKATION OF HENRY VIII (1520).

This engraving is taken from the large painting now in Hampton Court Palace ascribed to Vincent Volpe, a contemporary Court painter; it represents Henry VIII of England, with his fleet, leaving Dover Harbour for Calais, preparatory to his historical interview with Francis I of France, on the field of the Cloth of Gold

In the foreground are views of the two forts commanding the western side of the harbour entrance, while in the background appears Dover Castle Among the leading vessels, to the right of the picture, is shown the celebrated "Henri Grâce à Dieu" or "Great Harry," with the King standing upon the upper deck Interesting details are given of the masting, rigging, and external design and ornamentation of ships-of-war during the early part of the 16th century, these features are in general accord with the drawing of the "Henri Grâce à Dieu" in the Pepysian Library, Cambridge, a partial reproduction of which appears in an adjacent frame (No 26) Inv. 1905-19

26. PRINT OF "HENRI GRÂCE À DIEU" Presented by T. Dyer Edwardes, Esq, 1868.

This print from an engraving in the Pepysian Library, Cambridge, represents the "Henry Grâce à Dieu" of 1515

Various drawings of this ship are in existence, two of which (No 24 and No 25) are shown adjacently

This print of the hull agrees in general features with that shown in No 25 which probably more nearly represents the ship as actually built.

In 1538 she was rebuilt, this illustration probably representing her after that date.

After rebuilding her armament consisted of 19 brass and 103 iron guns Inv. 1868-138.

27. PRINT SHOWING A CORACLE AND SAILING SHIPS Presented by T Dyer Edwardes, Esq, 1868.

The vessels represented are —

(1) CORACLE, constructed of woven osiers lined with clay, such as was used by the Ancient Britons about 50 B C

(2) "GREAT HARRY," or "HENRI GRÂCE À DIEU," a warship of 1,000 tons burden and launched in 1515 She took part in the action against the French off the Isle of Wight in 1545, and was accidently burnt at Woolwich in 1553

(3) H M S "ROYAL JAMES," a first rate warship of 1,500 tons burden carrying 100 guns, launched in 1675

(4) H M S "ROYAL GEORGE," a first rate warship of 2,041 tons burden carrying 100 guns, and launched in 1756 In 1782 whilst being heeled for repair below the water line she sank at Spithead with a loss of 800 men Inv 1868-139.

28. PRINT OF 16th-CENTURY DUTCH WARSHIP. Presented by T. Dyer Edwardes, Esq, 1868.

This print by Frans Huys after Pieter Bruegel, represents a three-masted Dutch warship of the 16th century

The hull has lofty fore and after castles, the forecastle having considerable overhang The vessel is square rigged on fore and main, and lateen rigged on the mizzen mast The fore and main courses have bonnets, and upper and lower fighting tops are provided on the fore and main masts. These tops contain sheaves of darts, and protection is afforded by shields

The armament consists of 10 heavy guns, and many smaller guns, the after-castle carrying 13 of the latter on either broadside. At this period guns were provided in the bulkheads of the fore and after castles for the purpose of attacking boarders in the waist of the vessel These guns can be seen on the after side of the forecastle in the print, which also shows a protective netting in the waist. Inv. 1868-133.

29. PRINT OF 16th-CENTURY DUTCH WARSHIP. Presented by T. Dyer Edwardes, Esq., 1868.

This print by Frans Huys after Pieter Bruégel, represents a Dutch 16th-century warship provided with a considerable aftercastle, which extends from the mainmast to the stern

The vessel has four masts and is square rigged on the fore and main masts, while the mizzen and bonaventure masts are lateen rigged. She is apparently leaving harbour under her foresail, while preparations are being made to set the other sails.

The armament shown consists of 10 heavy, 14 medium, and 30 small guns, sheaves of darts being shown in all the tops Inv 1868–132

30. PRINT OF 16th-CENTURY DUTCH WARSHIP. Presented by T. Dyer Edwardes, Esq., 1868.

This print by Frans Huys after Pieter Bruegel, represents a 16th-century Dutch warship with four masts

The hull has high fore and after castles Boarding being usually effected at the waist, the after-forecastle and the forward-aftercastle bulkheads carried guns Inv 1868–131

31. PRINT OF WARSHIP (16th-century). Presented by T. Dyer Edwardes, Esq , 1868.

This print by John Gallé (1600–76) from an original by John Stradanus (1523-1605), represents a three-masted warship of the 16th century

The details shown include a boat at the stern, wheeled carriage guns on the quarterdeck, main and mizzen yards in two portions lashed together, and nettings in the waist to prevent boarding

The "battacle" for holding the compasses can be seen forward of the mizzen mast and the master of the vessel is shown taking a compass observation of the sun Inv 1868–134.

32. PRINT OF A NAVAL ACTION BETWEEN THE KNIGHTS OF ST JOHN AND THE TURKS (16th century) Presented by T Dyer Edwardes, Esq , 1868

This print represents an action between galleys, a type of vessel used largely in the Mediterranean at this time

The fighting was at close quarters, and the rowers were covered in by a platform on which were the combatants armed with swords or arquebusses In addition raised platforms were fixed at the bow and the stern

A ram was fitted in the bows, ramming being the first objective of the attack. Guns at the bow were usually discharged simultaneously with the ramming

Galleys at this time were rigged with two masts each carrying a large lateen sail, spread on a yard consisting of two portions lashed together Inv 1868–126

33. RIGGED MODEL OF ENGLISH MAN-OF-WAR (1580–1600) (Scale 1 : 72) Lent by R Morton Nance, Esq., 1908. Plate II. No. 2, p. 17.

This model of an Elizabethan warship was made by Mr Nance from information obtained from contemporary prints, paintings and detailed descriptions

The hull shows features of both the round-ship or mediæval merchant vessel, and the long-ship or war galley—a combination which gave a vessel capable of carrying a considerable spread of sail and ample armament while possessing the speed and handiness associated with lightness in construction. The narrowing or housing-in of the topsides, which rendered the vessel more seaworthy and strengthened the decks as gun platforms, as well as the beak-head and the open stern galley were new features of this period, while gratings and nettings in the waist as a defence against boarders were adapted from an earlier arrangement

Four masts are shown; the foremast is placed before the bulkhead of the forecastle and the bowsprit is stepped beside it, the two mizzen masts are fitted with lateen sails only, an outrigger from the stern being used to extend the sheet of the smaller or bonaventure mizzen-sail. On the ends of the bowsprit

and yard-arms are sheer-hooks intended for catching in an enemy's rigging No stay-sails were carried but the stays themselves were used for securing the standing parts of braces, bowlines, etc., the crow-foot being a favourite method of attachment. Marnetts or martinets, similar to leech lines, are shown upon the fore and main-sails, while the methods of furling adopted at this period are illustrated by the main-sail, fore top-sail and sprit-sail. The model is shown close-hauled with the fore-sail so canted as to resemble a lug-sail and having its tack hauled down to a comb-cleat under the head knee The detachable bonnet, an equivalent of reefing, shown laced to the fore-sail, and the striking of topmasts were innovations of this period

There is an armament of 30 large guns, besides which a number of small swivel-guns would have been carried.

The principal dimensions of the vessel are —Length, on gun deck, 80 ft , breadth, 26 ft ; depth of hold, 13 ft , displacement, about 450 tons

Inv 1908-99, S M 178

34. RIGGED MODEL OF ENGLISH MAN-OF-WAR (1550-1600). (Scale 1 : 48.) Lent by Freke Field, Esq , 1921.

This model represents an English galleon of the Elizabethan period, and shows the type of warship in use at the time of the Spanish Armada action in 1588

She carried 20 pieces of ordnance on the main deck and was pierced for 6 small guns on the upper deck Many lighter guns would be mounted on the bulwarks

The following interesting details may be noticed

(*a*) Two cressets (hollow vessels for carrying lights), which are fitted on brackets at the stern The flames were obtained from ropes smeared with pitch or resin

(*b*) The whipstaff, by which vessels of this period were steered This consists of a pivoted handle, the lower end of which engages with the end of the tiller while the upper end is moved from side to side by the helmsman, who was protected by a raised structure

(*c*) The figure head in the form of a lion, the carved cable moulding running round the ship, and the basket worked tops

Dimensions taken from the model —Length of keel, 92 ft , breadth, 30 ft , depth of hold, 15 ft The method of calculating tonnage varied considerably at this time, according to the method quoted by Sir William Monson in his "Naval Tracts," the model represents a vessel of about 420 tons burden

H M S "Revenge" was of similar dimensions and tonnage She was built at Deptford in 1575, carried 46 guns and had a ship's company of 250, composed of 140 mariners, 30 gunners and 80 soldiers Inv 1921-22, S M 1095

17th AND 18th CENTURY SHIPS OF WAR.

Although in preceding centuries great skill and forethought were devoted to the design and construction of the upper portion of a vessel, the underwater form followed practical traditions of uncertain value No systematic preliminary planning or arranging of a ship appears to have been made before the 17th century, though considerable advances were made at that time

Pepys in his diary, May 19th, 1666, with reference to Sir Anthony Deane, said "And then he fell to explain to me his manner of casting the draught of water which a ship will draw before-hand , which is a secret the King and all admire in him ; and he is the first that hath come to any certainty beforehand, of foretelling the draught of water of a ship before she is launched "

About this time "furrings" or "girdlings" were frequently added to a ship after construction for the purpose of increasing the breadth at the water line and hence the stability. Furring consisted of introducing packing pieces between the frames and the outside planking in the neighbourhood of the water line, while girdling was the addition of planking in the same region.

Two of the earliest builders to break away from long established usage and to produce vessels of greater size and speed were Peter and Phineas Pett, father and son, who built respectively the " Prince Royal " (1610) and the " Sovereign of the Seas " (1637) ; they reduced the heavy top-hamper and gave an improved under-water form to their vessels. About 1640, a systematic arrangement of pillars, or vertical supports, from keel to upper deck, was adopted, thus greatly strengthening the body

In the 17th century the warships of all European nations embodied the following features that have since disappeared :—High stern, decorated sides, square bulkhead across the bows, sprit topmast, sails below the bowsprit, and a lateen sail on the mizzen mast.

The larger English vessels had the "round-tuck " stern in which the outside planking was worked continuously to the stern post below the gun deck while the French, Dutch and Spanish had flat transom sterns (*see* No. **42**) The round-tuck was subsequently adopted by other countries The chain plates, for securing the dead eyes of the shrouds, were in English three-deckers on the level of the main deck while the French and Dutch placed the chain plates on the level of the upper deck. The latter was the better arrangement and was adopted by the English in 1705.

The 18th century was not an especially epoch-marking period in the development of shipbuilding though many important improvements were made About 1700, in order to decrease the expenditure on the Royal Navy, orders were issued prohibiting the extensive decoration which had been previously employed. The " Sovereign of the Seas " (1637) had been so gorgeously ornamented with carving and gilding that it was said " She seemed to have been designed rather for a vain display of magnificence than for the service of the State," and there had been a certain amount of opposition to this extravagance.

In 1706 an attempt was made to standardize the dimensions of the various classes of ships, and this assigned to English man-of-war inferior dimensions to French ships with corresponding armaments. In 1719 a new scale of dimensions was issued for vessels of each class, from the first-rate of 100 guns to the gun brig, and the constructor was not at liberty to depart from these dimensions An absence of development followed, and British ships became inferior in both size and sailing qualities to those of other powers Several engagements having demonstrated this result, the regulations were modified and new designs prepared giving larger dimensions and finer lines, which were partly obtained from those of captured vessels.

In 1710 a considerable gain in structural strength and durability was effected by the introduction of " cross timbers " connecting the lower portions of opposite frames, also a stout wood keelson and transverse " riders " above the floors, together with limber boards to facilitate the drainage of the bottom Remedies were also devised about 1715 for the injurious effects of bilge water and foul air in the holds, and about the same time the steering wheel appears to have come into use.

An important development about 1719 was the improvement in the method of preparing the timber. This had previously been prepared by charring the inner surface and keeping the outer surface wet until a plank could be brought into a condition fit for bending A stoving

process was, however, introduced in which the timber was placed in wet sand and heat applied in order that the material could be brought into the necessary pliable condition. Timber so treated remained in a good state of preservation for a longer period than that which had been treated by the older process. Later in the century a steaming process was introduced. Copper sheathing for ships' bottoms was first used in 1761, but as it was found to cause oxidization of the iron bolts "metal" was introduced in 1783 for the under water fastenings

During the 18th century the undesirable high stern of the earlier periods disappeared as well as the triangular lateen sail for the mizzen mast. In the earlier part of the century a jib boom for use with a fore-and-aft head sail was substituted for the earlier sprit topmast on the bowsprit.

35. ENGRAVING AND DRAWING OF H.M.S. "SOVEREIGN OF THE SEAS" (1637).

The engraving by J Payne gives a general view of the famous "Sovereign of the Seas," which was laid down at Woolwich in 1636 by Mr Peter Pett under the supervision of his father, Mr Phineas Pett, and launched in 1637

The first vessel with three flush decks, she was considered to be superior to any ship previously built and was so gorgeously ornamented with carving and gilding that it was said "she seemed to have been designed rather for a vain display of magnificence than for the service of the State" In 1637 Thomas Heywood wrote "She hath three flush Deckes, and a Fore-Castle, an halfe Decke, a quarter Decke, and a round house Her lower Tyre hath thirty ports, which are to be furnished with Demy-Cannon and whole Cannon throughout Her middle Tyre hath also thirty ports for Demi-Culverin, and whole Culverin, her third Tyre had Twentie sixe Ports for other Ordnance, her fore-Castle hath twelve ports, and her halfe Decke hath fourteene ports, She hath thirteene or fourteene ports more within Board for murthering peeces, besides a great many Loope-holes out of the Cabins for Musket shot She carrieth moreover ten peeces of chase Ordnance in her, right forward, and ten right aft . . . She carrieth eleaven anchors, one of them weighing foure thousand foure hundred, etc" (*i e*, lbs)

Her dimensions have been variously stated, Mr Thomas Heywood, in 1637, gave —tonnage, 1,637 tons, length of keel, 128 ft, length overall, 232 ft, breadth, 48 ft, height from keel to lanthorn top, 76 ft, Armament, 100 guns

In 1660 she was rebuilt and again in 1684, and was even then considered to be one of the finest ships in the world

The drawing by William Edye was copied from an unknown source in 1847, and as it differs from the original, it may represent the vessel after rebuilding It shows the sheer, half breadth, body plan and stern elevation, the following dimensions being given —burden, 1861 33/94 tons, length of gun deck, 173 ft, length of keel, 139 ft, breadth extreme, 50 ft, depth of hold, 20 ft This vessel was at different times also known as the "Royal Sovereign," the "Sovereign Royal," the "Sovereign" and the "Commonwealth"

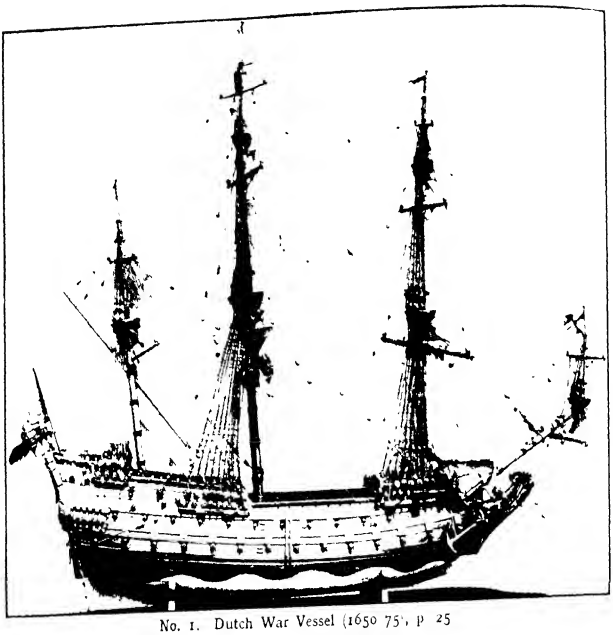
She took part in the action of the Kentish Knock, 1652, and in most of the actions of the Second (1665–67) and Third Dutch Wars (1672–74)

She was accidently burnt at Chatham in 1696 where she had gone to be rebuilt. Inv Nos 1905-163, 1894-231, 30,389, S M 751

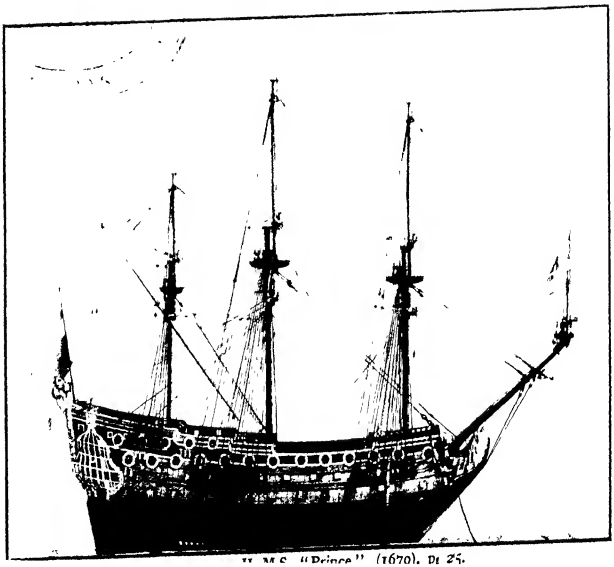
36. RIGGED MODEL OF A MALTESE GALLEY. (Scale 1 . 24.) Bequeathed by Miss M A. Peek, 1906.

This ancient model is believed to have belonged to the Knights of Malta It is planked on the starboard side, but shows the timbers on the port. Such armed vessels were usually rigged with three masts carrying large lateen sails, in calms they were propelled by sweeps, manned by slaves or convicts

The dimensions would be approximately —Length, 165 ft.; breadth, 22 ft., breadth from gunwale to gunwale, 31 ft; depth, 9·9 ft.; number of sweeps, 44. Inv. 1864-24, 31,662



No. 1. Dutch War Vessel (1650 75), p 25



H.M.S. "Prince" (1670). p. 25.

37. PRINT OF A 17th-CENTURY TURKISH WARSHIP. Presented by T. Dyer Edwardes, Esq., 1868.

This print of an illustration by Joseph Furttenbach, a contemporary artist, represents a carramuzzal.

This class of ship was used extensively by the Turk in the Mediterranean Sea at this time The hull is strongly constructed, and has the typical fore and after castles of the 17th century. The artist has omitted the masts and sails to show the action of the armament, she was rigged with two masts carrying large lateen sails

The armament consisted of guns of various calibres, the largest firing bomb shells, introduced in 1580. The crew are armed with calivers and crossbows, the latter firing arrows fitted with an incendiary head

Greek fire, a mixture of naptha, sulphur and pitch, is being blown through a copper tube in the bows. Inv. 1868–130.

38. PRINT OF 17th-CENTURY WARSHIP. Presented by T. Dyer Edwardes, Esq., 1868.

This print of an illustration by Joseph Furttenbach, a contemporary artist, represents a full-rigged ship of war of the 17th century

The rigging and other details appear to have been exaggerated for the purpose of clearness

The vessel is square-rigged, and carries a lateen sail on the mizzen mast, while the sprit-sail and fore and main courses are furled.

An armament of 23 guns is shown, the ship's side being painted in alternate light and dark coloured bands The general arrangement shows an advance in comparison with the preceding century, and there is an absence of the extreme lofty fore and after castles Inv 1868–129.

39. RIGGED MODEL OF DUTCH WAR VESSEL (1650–75). (Scale 1 72) Lent by R Morton Nance, Esq, 1903. Plate IV. No. 1. p. 25

This represents a man-of-war of the largest type in the Dutch Navy in the latter half of the 17th century, the model was made by Mr Nance from data obtained from contemporary drawings and some original models deposited in Continental churches At this period the naval power of Holland equalled that of any country, but the shallow waters of her coast and harbours so limited the draught of her ships that they were generally of less tonnage than those of other powers

The model shows the "square tuck" or "transom stern," common to the Dutch, Spanish and French men-of-war of the time, therein differing from the English rounded stern in which the outer planking was worked in continuous lines to the stern post The channels for securing the lower rigging of the fore and main mast are fitted above the upper deck gun-ports, an improvement which was not generally adopted in the English Navy till a century later The shape of the mast-caps, the circular tops, the use of a sprit-top mast, and of a lateen yard are also features of the period to which the model belongs.

The leading dimensions of the vessel would be approximately —Displacement, 1,600 tons, length, 120 ft, breadth, 42 ft, armament, 65 guns. Inv 1922–729, S M. 179.

40. RIGGED MODEL OF H M S "PRINCE" (1670) (Scale 1 : 48) Plate IV, No. 2, p. 25. and Plate V, No. 1, p 29.

This contemporary model shows a 17th-century line-of-battle ship of the first rate and represents H M S "Prince," sometimes called the "Royal Prince," which was built at Chatham in 1670 by Phineas Pett, and was pierced for 100 guns Her armament varied from 100 guns for war in home waters to 90 for war abroad

The "Prince" was broken up in 1692 her sound timber being used in the construction of the "Royal William"

The model was rigged in the Museum in 1898 from information collected from several drawings and models of the period Although shown without top-gallant yards, it is not to be inferred that such spars were not then in use, in fair weather they were commonly fitted, but during the winter season the usual rig was as here represented

The chief difference between this rig and that of vessels of the 19th century is in its having a sprit topmast and jackstaff on the bowsprit, and in the use of a large lateen yard and sail on the mizzen mast in place of a spanker spread by a gaff and a boom.

The tops throughout are circular in plan and have a raised ledge.

The armament of the period would be :—Lower deck, twenty-eight 42-prs., main deck, twenty-six 40-prs.; upper deck, twenty-six 18-prs.; quarterdeck and forecastle, sixteen 6-prs.

Her complement in peace was 560, in war abroad 670, in war at home 780.

Dimensions :—Tonnage, 1,463 tons, length of keel, 131 ft.; breadth, 45·8 ft; depth in hold, 19 ft, draught, 21·5 ft

At one time this model was wrongly supposed to represent H M S "Royal Charles" (1672), but it has now been identified

(*See* "The Mariners Mirror," p 151, Nov 1919)

Inv 1895-56, 27,946, S M 1159, S M. 1160

41. ENGRAVING OF A MAN-OF-WAR OF THE 17th CENTURY.

This represents a battleship of the first rate, mounting 100 guns, and having a complement of 710 men It probably belongs to the period 1660–80 Details of the lower transverse framing are shown, and the names of the various parts are given in English, German, French, and Italian The usual elaborate ornamentation of the upper portions of the hull is carefully represented

Her armament was :—Lower deck, twenty-eight 42-prs, middle deck, twenty-eight 40-prs, main deck, twenty-eight 18-prs, upper deck, twelve 16-prs; poop deck, four 6-prs

Tonnage, 1,672 tons, length, 136 ft, breadth, 44 5 ft; draught, 20 5 ft

Inv 1894-149

42. ENGRAVINGS OF 17th-CENTURY WARSHIPS OF THE SECOND-RATE. Presented by T Dyer Edwardes, Esq, 1868

These four prints from drawings by Vandevelde, illustrate the difference in the build of English and foreign warships about the year 1670

The English ship shows a clean run, her outside planking being worked continuously to the sternpost below the gun deck, while the planking of the foreign vessels terminates in flat transom sterns, the English and Spanish chain plates are on the main deck, whilst those of the French and Dutch are on the upper

Inv 1868-117 to 120

43. RIGGED MODEL OF ENGLISH HOY (1700-30) (Scale 1 : 72) Lent by R. Morton Nance, Esq, 1913

The "hoy" type originated in Holland and was largely used for cargo purposes from the 16th till early in the 18th century This model, built from a sheer draught of the period 1700–30, represents an armed vessel used as a naval tender or storeship

Above the waterline, the English hoy resembled a Dutch galliot (*see* model in Room 16) with the addition of a "lute" or overhung stern-piece Below the waterline the sections were finer than those of a galliot and no lee-boards were necessary

The main-sail, worked by means of brails, was carried on a heavy gaff or "half-sprit" A square sail, square topsail, fore-staysail, jib, and possibly a sprit sail were also carried Some hoys had a mizzen mast carrying a lateen yard or, at a later date, a gaff

It is interesting to note that the earliest yachts were rigged similarly to hoys and differed from them chiefly in being more lightly built and having a beak-head and square stern like ships-of-war

The principal particulars of this vessel are :—Burden, 154 tons; carrying capacity, 300 tons (approx), length, on deck, 79 ft, breadth, 21 ft., armament, 6 light guns.

Inv 1913-513.

44. WHOLE MODEL OF 60-GUN SHIP. (Scale 1 : 48) Lent by H. J. Daffarne, Esq.

This built model, which has its lower masts and bowsprit stepped and tops over, represents a fourth rate man-of-war built about 1715 on the "establishment for building ships framed in 1706," and carrying 60 guns

Burden, 914 tons ; length on gun deck, 144 ft. ; length of keel, 119 ft. ; breadth, 38 ft. ; depth in hold, 15·7 ft.

There is a tradition that this model represents H M S. " Chester," a fourth-rate of 50 guns, but the dimensions do not accord with that view.

Inv 1869-66, 16,288.

45. WHOLE MODEL OF ENGLISH THIRD-RATE. (Scale 1 60.) Lent by P. E. D. Hammond, Esq., 1917.

This represents an English third-rate line-of-battleship of the early part of the 18th century. The model is reputed to have been made about 1714 by Mr. Wm. Hammond, a naval architect, and to represent H.M S " Captain," a contemporary vessel built at Portsmouth in 1708

Her armament was —Lower deck, twenty-six 18 or 24-prs , main deck, twenty-eight 12-prs ; quarter-deck, twelve 6-prs , forecastle, four 6-prs , and the complement, 480 men.

Burden, 1,121 tons , length on gun deck, 150 ft , length of keel, 124 ft , breadth, 41·2 ft. , depth in hold, 17·3 ft.

Inv 1917-2

46. DRAWINGS OF BOW AND STERN OF " ROYAL WILLIAM " (1719). (Scale 1 : 48) Lent by the Rev. F. C P. Nash, M A., 1912.

These two drawings show the starboard extremities of the first-rate line-of-battle ship " Royal Wilham," of 100 guns, as rebuilt in 1719

Both views give full details of the external appearance of the hull, including the gun-ports and the elaborate ornamentation employed at this period The bow view extends to the break of forecastle and shows particulars of figure-head, beak bulkhead, bowsprit and foremast , the stern view extends to the break of poop and shows rudder, quarter galleries, lantern and mizzen mast

The original " Royal Wilham " is reputed to have been built at Chatham from designs by Sir Phineas Pett In 1719 the vessel was rebuilt to larger dimensions at Portsmouth under Mr Nash, master shipwright, and proved an excellent example of the durability of such structures, when built of well seasoned materials. She was reduced to a third rate of 84 guns in 1757, assisted at the relief of Gibraltar in 1782 and was Port-Admiral's flagship at Spithead until 1813, when she was taken to pieces

Her particulars, after 1719, were —Burden, 1,918 tons , length on gun deck, 174 3 ft , breadth, 50 3 ft , depth, 20 ft , complement, 750 men

Inv 1912-291

47. RIGGED MODEL OF ENGLISH BATTLESHIP. (Scale 1 64) Lent by Mrs. Humphry, 1905.

This represents an English line-of-battle ship of the third rate, built on the " establishment for building ships framed in 1719," and carrying 80 guns on three decks The class was described as inefficient , they were bad sea boats, being three-deckers on the dimensions of two-deckers , consequently none were built after 1757

The model itself is well and accurately rigged, showing snaked fore and main stays, the method of swifterng in the lower rigging, spritsail yard, sprit topmast and yard, the introduction of the jib-boom, and top cloths used for ornamental purposes

The armament was —Lower deck, twenty-eight 24-prs , middle deck, twenty-six 12-prs , upper deck, twenty-six 9-prs Complement, 650 men

The dimensions of third-rates on the 1719 establishment were —Burden 1,350 tons , length on gun deck, 158 ft , length of keel for tonnage, 128 ft , breadth, 44 5 ft. , depth, 18 ft

Inv 1905-161

48. PORTFOLIO OF RIGGING AND SAIL PLANS OF WAR-SHIPS, 18th CENTURY. (Scale 1 · 72.)

This portfolio contains rigging and sail plans for (*a*) first-rate, (*b*) second-rate, (*c*) third-rate British warships. The names of the ships are not given, but internal evidence shows that they belonged to the period 1705–20

Details are shown of the masts and spars, the standing and running rigging, the principal sails—including the lateen and sprit sail—and the method of working them A sheer plan and a body plan of each vessel are also shown

The portfolio is open to show the second-rate. Inv 1908-46

49. PORTFOLIO OF SHEER DRAUGHTS OF WARSHIPS, 18th CENTURY. (Scale 1 : 48.)

This portfolio contains sheer draughts of four fourth-rate British warships (1700–1719)

The sheer draught is the first set of drawings sent to the builder, it provides the necessary information for laying-off to full size the principal framing, and also gives a good external representation of the completed hull Each sheer draught comprises —(*a*) A sheer plan or side elevation showing positions of the decks, gun-ports, channels, masts, bow and stern decorations, etc , (*b*) a stern elevation showing details of the transom framing and the arrangement of after galleries and decorative work, (*c*) a half-breadth plan showing horizontal projections of the top sides, the principal decks, the load water-plane and of a number of equidistant level planes in the underwater body Near this plan are also some rabatted diagonals, showing the true form of a number of planes drawn diagonally in the body plan, they are of considerable value in the "fairing" process and also indicate the lines of heads and heels of frame timbers, (*d*) a body plan showing transverse outlines of the hull taken at a number of equidistant vertical stations, the curves of centres for describing the arcs which form portions of these outlines are also drawn in

The vessels' names, with particulars taken from the draught, are –

Name	Length on Gun Deck, Feet	Breadth extreme, Feet	Tonnage	Gun	Launched
"Exeter"	147	38 5	950	60	About 1700
"Strafford"	130	35 0	700	52	Plymouth, 1714
"Winchester"	130	33 5	700	52	,, 1717
"Deptford.. ..	131	35 25	700	50	Portsmouth, 1719

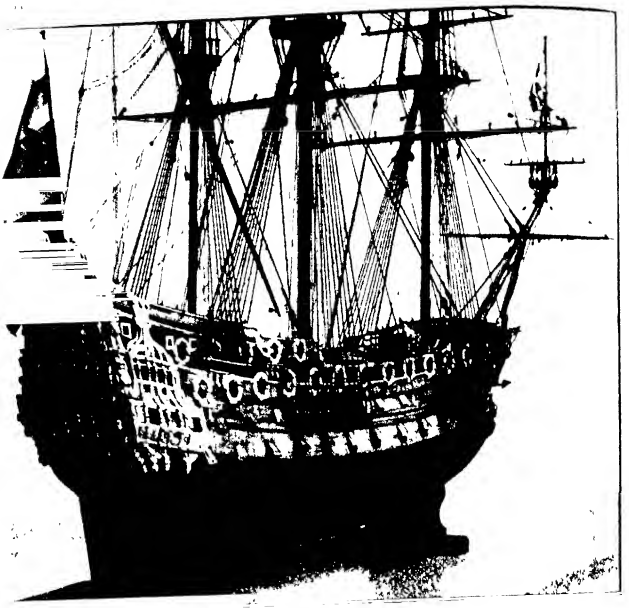
The portfolio is open to show the "Winchester" Inv 1908-45

50. PORTFOLIO OF CHARACTERISTIC "LINES" OF WARSHIPS, 18th CENTURY. (Scale 1 : 48.)

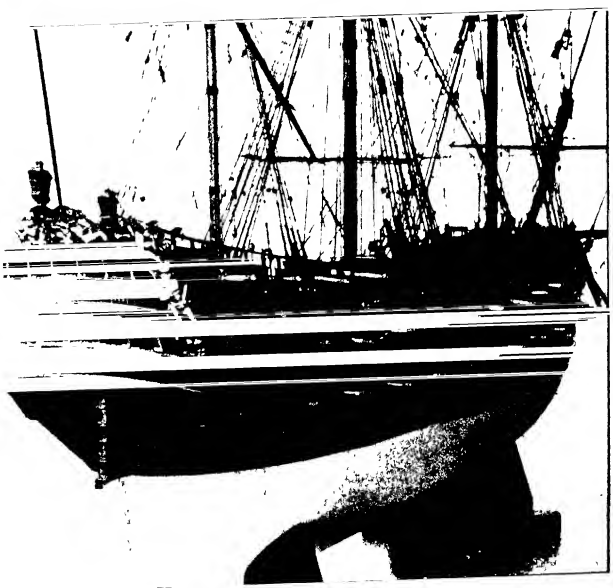
During the first half of the 18th century several attempts were made to standardize the design of the various classes of warships This portfolio, which was possibly intended for comparison in this respect, contains, superposed, characteristic curves of the 60-gun ships enumerated below, and shows the great diversity of form given to vessels of this class by the master shipwrights of different Royal dockyards The curves drawn to ordinates from a common base line, represent —(*a*) Outlines of the transverse midship sections; (*b*) Horizontal projections of the topsides and principal decks; (*c*) Horizontal projections of the load water-plane and of several under-water planes; (*d*) Rabatted diagonals, which show the true lines of intersection with the hull of a number of diagonal planes.

The portfolio is open to show the lines of the "Dragon" (1733), "Rippon" (1730), "Tilbury" (1730), "Weymouth" (1733) and "Superbe," the latter, a 56-gun ship captured from the French in 1710, shows generally a finer entrance and run as well as sharper midship floors then the British ships.

The vessels shown on the remaining two sheets are :—"Augusta" (1733), "Canterbury" (1741), "Jersey" (1733), "Kingston" (1736), "Princess Mary" (1737), "Rupert" (1736), "Strafford" (1733), "Worcester" (1733), and "unnamed" (1742). Inv. 1908–184.



No 1 H M S. "Prince" (1670), p. 25.



No. 2. English Fourth-rate (1740-45), p. 29.

51. OIL PAINTINGS OF H.M.S. "VICTORY." Presented by H.M. Queen Victoria, 1864.

This was a first-rate battleship of 100-guns built at Portsmouth in 1737. he was lost in the English Channel October 5th, 1744, when Admiral Balchen nd her crew of 1,100 men perished.

Armament :—Lower deck, twenty-eight 42-prs ; middle deck, twenty-eight 4-prs ; main deck, twenty-eight 12-prs ; quarter deck, twelve 12-prs. ; fore-astle, four 12-prs. Her complement was 1,100 men.

Tonnage, 1,921 tons ; length, 174·75 ft ; breadth, 50·5 ft. ; depth of hold 0·5 ft. Inv. 1864–12 A. & B.

52. RIGGED MODEL OF ENGLISH MAN-OF-WAR, FOURTH-RATE (1740–45). (Scale 1 : 48.) Plate V, No. 2, p 29.

This represents an English warship, built in accordance with the 1733 stablishment for 50-gun ships ; eight of these vessels were constructed between 740 and 1745 under Sir J Acworth, Surveyor of the Navy.

During the first half of the 18th century fourth-rates were counted as ships-f-the-line, capable of taking part in general engagements ; at a somewhat later ate, however, they were more commonly used for convoy duty, and third-rates r 64-gun ships (*see* Nos 63 and 85) were the smallest officially recognised for ne-of-battle.

The following contemporary features are illustrated by the model :—(*a*) jib-boom, for use with a fore-and-aft head sail, now first substituted for the ort topmast, yard and square sail ; (*b*) the swiftering, or cross connection, of ch pair of shrouds on the fore and main masts, (*c*) the fitting of crows-foot gging, from the fore edges of the tops to the lower stays ; (*d*) lateen yard, with ttings, on the mizzen mast ; (*e*) spare spars, stowed in the waist, (*f*) portable h davit for lifting anchors ; (*g*) ornamentation of stern and topsides

The ordinary complement for these ships was 300 men, and the armament as usually distributed as follows —Lower deck, twenty-two 18-prs or 24-prs. ·5 ft long, upper deck, twenty-two 9-prs or 12-prs 8·5 ft long, quarter deck, ur 6-prs 7 ft long, forecastle, two 6-prs 8 ft long Provision was often ade for carrying several guns in excess of this number

The average dimensions of this class were :—Tonnage (b o m), 860 tons ; ngth on gun deck, 134 ft., breadth, 38·7 ft ; depth of hold, 15·75 ft. Inv 1909–123, S M. 210, S M 1652, S M. 1653.

53. WHOLE MODEL OF AN 18th-CENTURY LINE-OF-ATTLE SHIP ON LAUNCHING WAYS. (Scale 1 : 60.)

This is an English warship of the fourth rate, mounting 64-guns, H M S. Yarmouth," built at Deptford by Mr J Allen in 1745, was a similar vessel, id her dimensions were —Tonnage, 1,359 tons, length, 160 ft ; breadth, ·25 ft ; depth of hold, 19 ft

The model shows the method of launching used in the 18th century. The igs displayed are —The royal standard of the House of Hanover, 1714–1801 ; e Union Jack prior to the abolition of the Irish Parliament in 1801, the foul ichor of the Lords Commissioners of the Admiralty Inv. 1890–103.

54. RIGGED MODEL OF H M S "TRYAL" (Scale about 1 : 48)

This rough model, although obviously unreliable as regards scale and some tails, represents several of the features of a sloop-of-war of about 1750.

H M.S "Tryal," when built in 1741, was a sixth-rate sloop carrying 14 guns id 14 swivels, and it is believed that this model represents that vessel

The approximate dimensions are —Tonnage (b o m), 272 tons, length, ·4 ft. ; breadth, 26·1 ft , depth, 12 ft Inv 1886–106.

55. ENGRAVINGS OF ENGLISH MEN-OF-WAR OF THE th CENTURY.

These show details of line-of-battle ships of about 1750 The upper view presents a full-rigged 64-gun ship at anchor, and is provided with a marginal y that gives the names of the various ropes, spars, etc The lower view is a ngitudinal section of the hull of a 90-gun ship, showing the internal construction d fittings, this also is provided with a similar key. Inv 1892–90.

56. RIGGED MODEL OF AN ENGLISH FRIGATE OF THE 18th CENTURY. (Scale 1 : 48.) Bequeathed by T. S. Robins, Esq., 1881.

This 24-gun frigate was built about 1750 Amongst the interesting details visible are the upper and lower lateen yards on the mizzen mast, the method of stowing bower and sheet anchors, the timbers and upper deck beams, and a series of oar ports for use when becalmed.

The guns were 9-prs , and the ship's complement 160 men

The approximate dimensions would be —Tonnage, 511 tons ; length on gun-deck, 113 ft., length of keel, 93 ft , breadth, 32 ft , depth of hold, 11 ft Inv 1881-51, 25,225

57. OIL PAINTING, "LAUNCH AT DEPTFORD DOCK-YARD" (about 1750). Painted by J Clevely.

This yard, established early in the reign of Henry VIII, was closed for shipbuilding in April, 1869, and is now used as one of the principal victualling establishments for the Navy The picture shows very accurately the rig of the different ships at anchor, also the uniforms of the period Inv 1866-9

58. WHOLE MODEL OF H.M.S. "HAPPY" (Scale 1 48) Presented by the Admiralty, 1920

This 8-gun sloop designed by Mr Edward Allen, was laid down at Woolwich Yard in 1753, and was launched the following year She was lost in 1764

Her armament consisted of eight 3-prs and ten 5-pr swivels Tonnage, 140 tons , length, 75·5 ft , breadth, 20·6 ft , depth, 9 3 ft Complement, 50 men Inv 1920-283

59. OIL PAINTINGS OF ARMED CUTTER "ALERT" Presented by Mrs Gibbs, 1904.

These two paintings, dated 1755, represent an armed cutter or sloop-of-war, similar to a class of 8-gun vessels built in 1753 4 from the designs of Sir J Acworth

Many such vessels were built or purchased for the Navy during the latter half of the 18th century , they varied in size from 50 to 200 tons and were chiefly employed for the suppression of smuggling, which was at its height at that period

The vessel shown would have a complement of about 60 men Tonnage (b o m), 145 tons , length, on gun deck, 75 5 ft , length on keel, 62 ft , breadth, extreme, 21 ft , depth of hold, 9 5 ft Inv 1904-26

60. OIL PAINTINGS OF H M S "ROYAL GEORGE" Presented by H M Queen Victoria, 1864

These show bow and stern views of H M S "Royal George," a first-rate battleship of 100 guns She was laid down at Woolwich in 1746, launched in 1756, and foundered at Spithead, August 29th, 1782, in consequence of her "being heeled to come at the pipe that leads to the well" She remained in the spot where she had sunk until 1839, when by means of the diving bell many of her guns and stores were recovered, her hull being then blown up

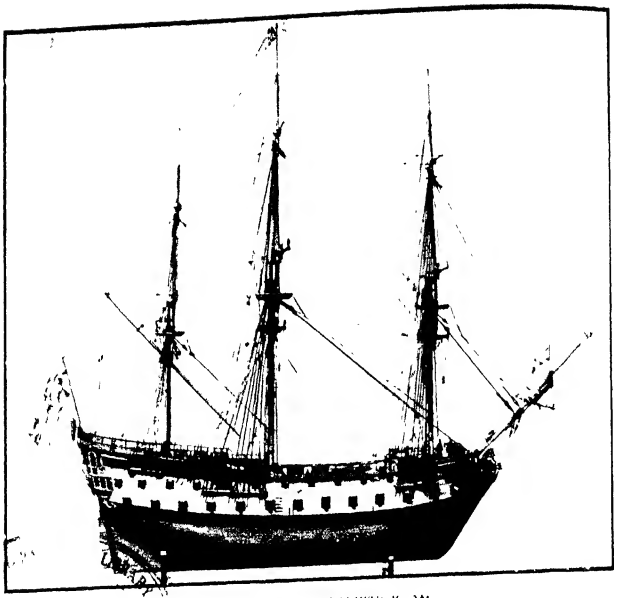
Her armament was —Lower deck, twenty-eight 42-prs , middle deck, twenty-eight 24-prs , main deck, twenty-eight 12-prs , quarter deck, twelve 12-prs , forecastle, four 12-prs Her complement was 800 men

Tonnage, 2,041 tons , length, 178 ft , breadth, 51 75 ft., depth of hold, 21·5 ft Inv 1864-13 A & B

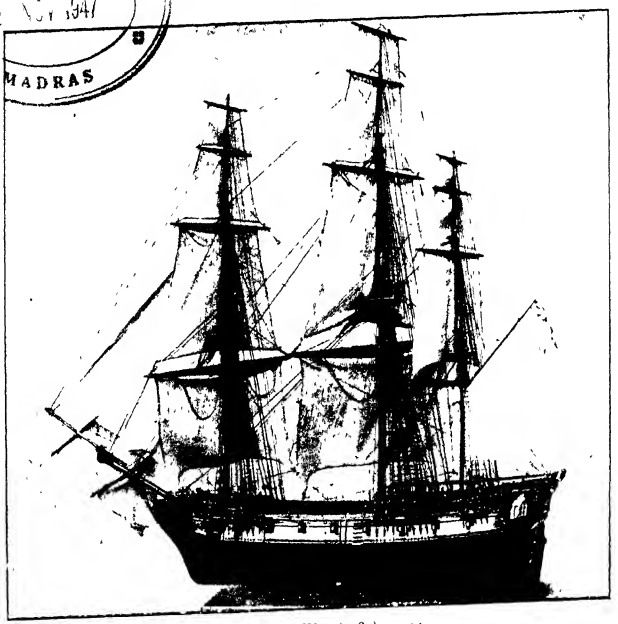
61. BUILT HALF-MODEL OF 50-GUN FRIGATE (1743-63) (Scale 1 : 48.)

This shows the above-water form of an English fourth-rate man-of-war built during the middle of the 18th century

H M S "Romney" laid down at Woolwich in 1759 and launched in 1762, was typical of the class and had the following principal dimensions :—Length on gun-deck, 146 ft , length on keel, 120·7 ft. ; breadth, extreme, 40·37 ft , tonnage (b o.m), 1,046 tons



No. 1 64-gun Ship (1794), p. 34.



No. 2 Sloop-of-War (1780), p. 34.

Although nominally rated as 50-gun frigates these vessels carried 54 and occasionally 58 guns. The bulwarks and gun ports to the poop-deck were probably additions, made during reconstruction at a later date. Inv. 1899–29.

62. BUILT MODEL OF H.M.S. "TRIUMPH." (Scale 1 : 48.)

This two-decked 74-gun line-of-battle ship was launched at Woolwich Dockyard in 1764 She was designed by Sir Thomas Slade on the lines of the "Invincible" captured from the French by Lord Anson and Sir Peter Warren on the 3rd of May, 1747.

Her armament was :—Lower deck, twenty-eight 32-prs , main deck, thirty 18-prs ; quarter deck, twelve 9-prs , forecastle, four 9-prs. Her complement was 650 officers and men.

Tonnage, 1,825 tons , length, 171·25 ft , breadth, 49·75 ft ; depth of hold, 21·25 ft Inv. 1892–89, 31,086.

63. RIGGED MODEL OF 64-GUN SHIP. (Scale 1 : 48.) Plate VI, No. 1. p. 31.

From 1719 till about 1745 the British ships-of-war were constructed upon a fixed scale of dimensions, with the result that, through the absence of development, our ships of each class became inferior in both size and sailing qualities to those of other powers , several engagements having demonstrated this result, the regulations were abandoned and new designs prepared giving larger dimensions and finer lines which were partly obtained from those of captured vessels

The model built by Messrs Perry & Co , and rigged in the Museum in 1901, represents a man-of-war of the third-rate built on the new system in 1764 by John Perry at Blackwall from designs by Sir T Slade of the Admiralty. It shows in detail the fittings of the improved vessels, including the cabin, belfry, riding bitts, galley, capstans, and the glazing of the stern and quarter galleries, with other details of the period

The armament would be :—Lower deck, twenty-six 18 or 24-prs , main deck, twenty-six 9-prs , quarter deck, ten 9-prs , forecastle, two 9-prs. Ship's complement, 500 men

The name of the vessel represented is uncertain, but her leading dimensions were probably :—Tonnage, 1,380 tons , length on gun deck, 159·3 ft , length on keel, 130·75 ft , breadth, 44 5 ft , depth, 18·75 ft Inv 1899–32, 27,947

64. ENGRAVING OF H.M.S. "VICTORY" (1765).

This contemporary engraving dated 1781, represents H M S "Victory," a first-rate of 104 guns passing Dover under sail for the Downs.

She was built in 1759–65 at Chatham to the designs of Sir Thomas Slade, and was first commissioned in 1778 Between 1783 and 1793 she had two "middling repairs" and one "large repair," and in 1800–1803 she was rebuilt She took part in the Battle of Trafalgar where she flew the flag of Admiral Nelson

The "Victory" finished her sea-going service in 1812 after having been the flagship in the Baltic in 1809 and 1811, and off Spain in 1810

She was rebuilt 1814–16 when the old beak-head and square bulkhead were converted into the built up round bow, and the stern galleries taken down.

The vessel was commissioned as flagship of the Port Admiral at Portsmouth at various periods between 1824–36, as flagship of the Admiral Superintendent between 1836–47, as flagship of the Commander-in-Chief between 1848–69, as tender to the flagship between 1869–91, and again as flagship from this date up to the present time

In 1922 her condition was so grave as to necessitate her removal into dry dock and on further examination it was decided that she was no longer fit to remain afloat It is, however, now intended to renovate her and, as far as possible, to restore her to her appearance at the time of the Battle of Trafalgar

The following dimensions are those at the time when Admiral Nelson hoisted his flag on board in 1803. Her armament was :—Gun deck, thirty 32-prs ; middle deck, twenty-eight 24-prs ; upper deck, thirty, 12-prs , quarter deck, ten 12-prs ; and forecastle, two 12-prs. Complement, 850 men Burden, 2,162 tons. Length of gun deck, 186 ft , length of keel for tonnage, 153·1 ft ; breadth, 51·5 ft. depth of hold, 21·5 ft Inv 1912–104.

65. OIL PAINTINGS OF H.M.S. "BARFLEUR." Presented by H.M. Queen Victoria, 1864.

This was a second-rate battleship of 90 guns, laid down at Chatham in 1762, launched 1768, and broken up in 1819.

Armament:—Lower deck, twenty-eight 32-prs.; main deck, thirty-two 18-prs; upper deck, thirty 9-prs. Her complement was 750 men.

Tonnage, 1,750 tons, length, 177·6 ft., breadth, 50·4 ft.; depth of hold, 21 ft. Inv. 1864–11 A & B

66. OIL PAINTINGS OF H.M.S. "ROYAL OAK." Presented by H.M. Queen Victoria, 1864.

This was a third-rate battleship of 74 guns, laid down at Devonport in 1766, launched 1769, and broken up in 1815.

Armament.—Lower deck, twenty-eight 32-prs., main deck, twenty-eight 18-prs., quarter deck, fourteen 9-prs., forecastle, four 9-prs. Her complement was 650 men.

Tonnage, 1,606 tons, length, 168·5 ft, breadth, 46·75 ft, depth of hold, 20 ft Inv. 1864–10 A & B

67. OIL PAINTINGS OF H.M.S. "INTREPID." Presented by H.M. Queen Victoria, 1864

This was a third-rate battleship of 64 guns, laid down at Woolwich in 1707, launched 1770, and sold out of the Service in 1828

Armament.—Lower deck, twenty-six 24-prs., main deck, twenty-six 18-prs, quarter deck, ten 9-prs., forecastle, two 9-prs. Her complement was 500 men

Tonnage, 1,374 tons, length, 159·5 ft, breadth, 44 4 ft, depth of hold, 19 ft Inv. 1864–9 A. & B

68. OIL PAINTINGS OF H.M.S. "KINGFISHER." Presented by H.M. Queen Victoria, 1864

This was a 14-gun sloop-of-war laid down at Chatham in 1769, launched 1770, and burnt at Rhode Island in 1778

The armament was fourteen 6-pr. guns, and the complement 125 men

Tonnage, 302 tons, length, 98 75 ft, breadth, 26 83 ft, depth of hold, 12 ft Inv. 1864–3 A & B.

69. OIL PAINTINGS OF H.M.S. "PORTLAND." Presented by H.M. Queen Victoria, 1864

This was a fourth-rate battleship of 50 guns, laid down at Sheerness in 1767, launched 1770, and sold out of the Service in 1807

Armament.—Lower deck twenty-two 24-prs., main deck, twenty-four 18-prs, quarter deck, four 9-prs. Her complement was 350 men

Tonnage, 1,044 tons, length, 146 ft, breadth, 40 5 ft, depth of hold, 17·5 ft Inv. 1864–8 A & B.

70. OIL PAINTINGS OF H.M.S. "AMBUSCADE." Presented by H.M. Queen Victoria, 1864

This was a fifth-rate battleship of 32 guns, laid down at Messrs. Adams & Co.'s yard on the Thames in 1771, and launched in 1773. She was taken by the "Bayonnaise" in December 1798, and afterwards retaken and broken up in 1813

Armament.—Main deck, twenty-six 12-prs., quarter deck, four 6-prs, forecastle, two 6-prs. Her complement was 215 men

Tonnage, 684 tons; length, 126 25 ft, breadth, 35 16 ft, depth of hold, 12·16 ft Inv. 1864–6 A & B

71. OIL PAINTINGS OF H.M.S. "ENTERPRIZE." Presented by H.M. Queen Victoria, 1864

This was a sixth-rate battleship of 28 guns, laid down at Deptford in 1771, launched in 1774, and broken up in 1807.

Armament.—Main deck, twenty-four 12-prs, quarter deck, four 6-prs. Her complement was 200 men

Tonnage, 594 tons; length, 120·5 ft.; breadth, 33·5 ft.; depth of hold, 11 ft. Inv. 1864–5 A. & B.

72. OIL PAINTINGS OF H.M.S. "EXPERIMENT." Presented by H.M. Queen Victoria, 1864.

This was a fourth-rate battleship of 50-guns, laid down at Messrs. Adams & Co.'s yard on the Thames in 1772, and launched in 1774.

She was dismasted in a gale and taken by the French fleet in 1779 on her passage from New York to Savannah

Armament:—Lower deck, twenty 24-prs.; main deck, twenty-two 18-prs.; quarter deck, six 9-prs.; forecastle, two 9-prs. Her complement was 300 men.

Tonnage, 923 tons; length, 140·75 ft.; breadth, 38·75 ft; depth of hold, 16·58 ft. Inv. 1864–7 A. & B.

73. OIL PAINTINGS OF H.M.S. "SPHINX." Presented by H M. Queen Victoria, 1864.

This was a sixth-rate battleship of 20 guns, laid down at Portsmouth in 1773, and launched in 1775 She was taken by the French in 1779, retaken the same year by H M S "Proserpine," and broken up at Portsmouth in 1811.

Her armament was twenty 6-prs, and complement 160 men

Tonnage, 429 tons; length, 108 ft., breadth, 30 ft, depth of hold, 9·6 ft Inv. 1864–4 A. & B

74. OIL PAINTINGS OF AN ENGLISH WARSHIP. Presented by F. A B. Bonney, Esq., 1865.

These represent a third-rate battleship mounting 64 guns The paintings, which are on copper, were used in the royal nursery for the instruction of Prince Wilham Henry, afterwards William IV

Armament.—Lower deck, twenty-six 24-prs, main deck, twenty-six 18-prs, quarter-deck, ten 9-prs., forecastle, two 9-prs. Her complement was 500 men.

The leading dimensions of such a ship would be about —Tonnage, 1,374 tons, length, 157 5 ft, breadth, 44 5 ft, depth of hold, 19 ft. ½ Inv 1865-16 A. & B.

75. WHOLE MODEL OF ENGLISH MAN-OF-WAR. (Scale 1 48)

This represents a third-rate 70-gun ship, similar to H M S. "Boyne," built at Plymouth in 1776

Her armament was —Lower deck, twenty-six 32-prs, main deck, twenty-six 18-prs, upper deck, twelve 9-prs, poop, six 6-prs Her complement was 520 men

Tonnage, 1,426 tons, length, 162 ft, breadth, 44 66 ft., depth of hold, 19 33 ft. Inv 1894–187

76. RIGGED MODEL OF "LE SCEPTRE." (Scale 1 : 96).

This represents a French line-of-battle ship of 74 guns, which took part in some of the most important actions during the war 1778–82.

Her armament was:—Lower deck, twenty-eight 36-prs., main deck, thirty 18-prs; quarter-deck and forecastle, sixteen 8-prs Her complement was 690 men

Tonnage, 1,832 tons, length, 173·6 ft, breadth, 49·6 ft., depth of hold, 21·6 ft. Inv. 1871–5.

77. BUILT MODEL OF H.M.S. "CLEOPATRA" (1779). (Scale 1 : 48.)

This 32-gun frigate was built at Bristol in 1779 from the designs of Sir J. Williams, Surveyor of the Navy. She was captured near the West Indies on 17th February, 1805, by the French 40-gun frigate "Ville de Milan," but was retaken, with her captor, by the British 50-gun frigate "Leander" six days afterwards.

The model shows all the important structural details and fittings of lower, main, quarter, and forecastle decks and also the general system of colouring and decoration adopted at this period.

The ship's complement was 222 men and, at the date of this action, her armament probably consisted of twenty-six long 18-prs. on the main deck, two long 9-prs. together with ten 24-prs. (carronades) on the quarter and forecastle decks.

Tonnage (b o m.), 689 tons, length, on gun-deck, 126·4 ft; length of keel, 104·5 ft.; breadth, 35·2 ft.; depth, 12·1 ft.

The vessel is represented on a building slip ready for launching The launching arrangements consist of (*a*) A fixed wooden structure or "ground ways" built up from the floor of the ship-way and forming an inclined plane usually with a fall of ·625 in to 1 ft. (1*e*, 1 in 19), (*b*) two movable structures forming a "cradle," extending over three-fourths of the vessel's length, by which the whole weight of the hull is carried Premature sliding of the cradle down the ways is prevented by short diagonal props or "dog shores," shown on each side of the ship at the upper end of the ways, the dog shores are knocked away simultaneously when the launching operations begin To prevent lateral movement of the cradle during its downward course, stout battens or "ribbands" are fitted to the upper edge of the ground-ways and held in position by the series of transverse props or shores shown on each side of the shipway

Inv 1907–50, S M 24

78. HALF-MODEL OF THE "SANTA MONICA." (Scale 1 48) Presented by the Admiralty, 1920

This 44-gun frigate was captured from the Spaniards in 1779 by H M S "Pearl" She struck a rock and was lost on April 1st, 1782, near Norman's Island, one of the keys of the Virgin Islands

Her armament consisted of —Main deck, twenty-six 12-prs, upper deck, ten 6-prs, and eight 18-pr carronades, and the complement was 225 men

Tonnage, 956 tons, length 145 ft, breadth, 38 7 ft, depth, 11 8 ft

Inv 1920-226

79. HALF-MODEL OF THE "SANTA MARGARITTA" (Scale 1 : 48.) Presented by the Admiralty, 1920

This 36-gun frigate was captured from the Spaniards in 1780 Her armament consisted of – Main deck, twenty-six 12-prs, quarter deck, eight 6-prs, and forecastle, two 6-prs

Tonnage, 993 tons, length, 145 5 ft, breadth, 38 9 ft, depth, 11 7 ft

Inv 1920-227

Complement, 255 men

80. HALF-MODEL OF THE "GRANA" (Scale 1 · 48) Presented by the Admiralty, 1920

This 28-gun frigate was captured from the Spaniards off Cape Finisterre on the 25th of February, 1781, by H M S "Cerberus" of 32 guns under Capt Mann

Her armament consisted of twenty-two 6-prs, and six 4-prs, and her complement of 180 men

Tonnage, 528 tons, length, 117 8 ft, breadth, 32 ft, depth, 9 3 ft

Inv 1920-213

81. RIGGED MODEL OF ENGLISH SLOOP-OF-WAR, 18th CENTURY. (Scale 1 . 48) Plate VI, No 2, p. 31

This represents a ship-rigged sloop of about 1780, which carried eighteen 6-pr guns and 125 men

The masting rigging and sails of the model were added in the museum in 1904–5

Approximate dimensions —Tonnage (b o m), 300 tons, length of gun deck, 100 ft, length of keel, 82 ft, breadth, 26·3 ft, depth of hold, 12 ft

Inv 1881–33, 28,308.

82. RIGGED MODEL OF ENGLISH SLOOP-OF-WAR. (Scale 1 : 48.)

This represents a schooner-rigged sloop-of-war built about 1780 The term sloop-of-war was applied to a class of vessel carrying from 4 to 18 guns, and rigged as schooner, brig, or ship, they were used to cruise against privateers

or in the prevention of contraband trade. The model was rigged in the Museum in 1902.

The armament would be about twelve 6-prs., and the complement 30 to 50 men

The approximate dimensions of the schooner represented were:—Length of keel, 56 ft , breadth, 20·5 ft , depth of hold, 8 ft , tonnage (b o m), 120 tons

N B —In the Merchant Service the term sloop was confined to a type of single-masted vessel resembling a cutter, but having also a square sail

Inv 1881-34, 27,948.

83. HALF-MODEL OF H.M.S. "ESPION" (Scale 1 : 48.) Presented by the Admiralty, 1920.

This 32-gun frigate, built in 1782 as "Atalante," was captured from the French in 1794 She was wrecked on the Goodwin Sands, 1799

The armament consisted of twenty-six 12-prs , and six 6-prs , and the complement of 215 men

Tonnage, 986 tons , length on gun deck, 147·8 ft , length of keel, 122 7 ft , breadth, 38 9 ft. Inv 1920-215

84. RIGGED MODEL OF 32-GUN FRIGATE. (Scale 1 : 48.)

The frigate, a fast vessel of medium size carrying her main armament on one deck, appears to have been generally introduced into the Royal Navy about 1756 The original vessels, of 28 to 32 guns and 600 to 700 tons burden, having proved highly successful for scouting and independent cruising purposes, the type gradually increased in numbers and dimensions , early in the 19th century vessels of 50 to 60 guns and 1,500 tons burden were built and when steam propulsion was introduced in 1850, the last of the sailing frigates had reached 2,100 tons burden

This model was rigged in the Museum in 1907 , it agrees in general dimensions with a class of 32-gun frigates built in 1783–6 from the designs of Sir J Williams These were classed as fifth-rate vessels and the "Meleager," a typical ship, built in 1785, had the following principal particulars —Ship's complement, 220 men , armament, twenty-six 12 or 18-prs on main deck , four 6-prs on quarter-deck , two 6-prs on forecastle deck Dimensions Tonnage (b o m), 678 tons , length on gun deck, 126 ft , breadth, 35 ft , depth, 12·15 ft.

Inv 1877-427, S M 23.

85. RIGGED MODEL OF ENGLISH 64-GUN SHIP. Period 1780–90. (Scale 1 48)

The vessel represented is a man-of-war of the third rate at the close of the 18th century The model was rigged in the Museum in 1902 , it differs chiefly from the similar ship of about 1760 (No 63) in having a gaff instead of a mizzen or lateen yard

The lateen yard, inclined at about 45 deg and used for spreading a triangular sail, had been employed for centuries for carrying the fore-and-aft sail on the mizzen mast of warships, but in the 18th century the present gaff or half-yard began to be adopted At first the gaff was confined to ships carrying less than 50 guns, but by the end of the 18th century it had completely supplanted the lateen yard, probably through the inconvenience of the latter, and the difficulty in working it.

The vessel is shown carrying three poop lanterns and a lantern in the maintop, these giving by night the distinguishing mark of a flag officer's ship Across the forecastle is a "fish-davit"—a spar used in the 18th century for fishing the anchors , in the *Naval Expositor* (1752) it is thus described —"A piece of timber in a ship, having a notch at one end, in which by a strap hangs a block called the fish-pendant block, the use of which is to haul up the flook of the anchor, in order to fasten it to the ship's bow; this davit is shiftable from one side to the other as occasion requires"

Armament —Lower deck, twenty-six 32-prs , main deck, twenty-six 24-prs , upper deck, twelve 12-prs. Her complement was 500 men.

Tonnage, 1,374 tons , length on gun-deck, 159·5 ft ; length of keel, 131 ft ; breadth, 44 5 ft. , depth, 19 ft. Inv. 1881-31, 27,949.

B 2

86. RIGGED MODEL OF FRENCH THREE-DECKER. (Scale 1 : 144.) Bequeathed by C. R. Leighton, Esq., 1921.

This model represents a French battleship of 120 guns of about 1780-1800, and was made by French prisoners-of-war

The model illustrates one of the largest first-rate ships of the period, which according to the French rule of 1786 were of the following dimensions - Tonnage, 2,500 tons; length (b.p), 196·5 ft.; breadth, 50 ft.; depth in hold, 25 ft.; complement, 1,098 men.

The armament was :—Lower deck, thirty-two 36-prs ; middle deck, thirty four 32-prs.; upper deck, thirty-four 12 prs., forecastle and quarter-deck, twenty 8-prs. Inv 1921-138, S M 1849

87. SEPIA DRAWING OF A GALLEY AND H.M.S. "SANS-PAREIL" (1794).

This drawing, by J. T Serres (*b* 1759, *d* 1825), represents a longitudinal section of a galley as used in the Mediterranean. Such craft had usually two masts carrying lateen sails

The references to details are —(*a*) Sick quarters, (*b*) Surgeon's chest, (*c*) Rope, sail and shot store, (*d*) Canteen, (*e*) Powder magazine, (*f*) Bread and vegetable store, (*g*) Wine and meat store, (*h*) Captain's provision store, (*i*) Council chamber, (*k*) The cabin, (*l*) Swivel guns

The "Sanspareil" was an 80-gun ship, captured from the French on June 1st, 1794, and broken up at Devonport in 1842 As the sketch was made on June 24th, 1794, it probably represents the dismasted ship as she appeared on June 13th, when being towed into Portsmouth Harbour with six other prizes. Inv 1890 149

88. MODEL OF H M S "BOYNE" (1790) (Scale 1 : 48) Bequeathed by Algernon Brent, Esq., 1916. Plate VIII, No. 1, p. 50 and Plate IX, No 1, p. 50.

This represents a three-decked line-of-battle ship, second-rate, carrying 98 guns and built at Woolwich in 1790 under the surveyorship of Edward Hunt In 1794, under Admiral Sir J Jarvis, this vessel took part in the capture of Martinique, St Lucia and Guadaloupe, she was accidently burnt at Spithead in 1795

Details of external structure, fittings and decoration are shown A well executed equestrian carving of King William III forms the figure-head

The probable distribution of armament was as follows —Lower deck, twenty-eight 32-prs ; middle deck, thirty 18-prs ; upper deck, thirty 12-prs , quarter deck, eight 12-prs , forecastle, two 12-prs

The main particulars of the vessel were :—Burden, 2,010 tons, length, gun-deck, 182 ft , breadth, 50·25 ft , depth, 21 75 ft , complement, 750 men

Two earlier wood-built vessels of this name were constructed for the Navy in 1692 and 1766, respectively, and one later vessel in 1810

Inv 1916-46, S M 1508, S M. 1650, S M 1651

89. BUILT MODEL OF H M S. "QUEEN CHARLOTTE" (Scale 1 : 48) Lent by Hyde Clarke, Esq, D C L., 1881.

This 100-gun three-decked line-of-battle ship was designed by Mr Edward Hunt, as a sister ship to the "Royal George," and launched at Chatham in 1790 She was Lord Howe's flagship in the action off Brest, 1st June, 1794, and was accidently burnt off Leghorn in 1800.

The armament was :—Lower deck, thirty 32-prs., middle deck, twenty-eight 24-prs ; main deck, thirty 18-prs ; quarter-deck, ten 12-prs , forecastle, two 12-prs.

Tonnage, 2,286 tons; length, 190 ft.; breadth, 52·5 ft.; depth of hold, 22·3 ft. Inv 1881-30.

90. LITHOGRAPH OF "L'OCEAN."

This lithograph after a painting by M A. Mayer, represents the French three-decked line-of-battle ship "L'Ocean" of 120 guns in a gale in the Mediterranean on January 25th, 1841.

She was launched at Brest 1790 to the designs of Baron J N. de Sane, rebuilt in 1804, 1818 and 1837, and took part in the actions of June 1st, 1794, and April 11th, 1809, against the British

She bore the names "Etats de Bourgogne," "Ocean," "Montagne," "Peuple," "Ocean," in succession, and was broken up in 1855 in the same dock in which she was built.

Complement in war, 1,098; and in peace, 764 men.

Length, 196·75 ft.; breadth, 50 ft.; depth in hold, 25 ft. Inv 1921–1018.

91. WHOLE MODEL OF FRENCH THREE-DECKER. (Scale about 1 : 144.) Lent by Vaughan Pendred, Esq, 1876.

This model in bone was made by French prisoners during the Peninsular War of 1807–14 It represents one of the largest first-rate ships of that period, probably a similar vessel to the "Commerce de Marseilles," a 120-gun line-of-battle ship captured at Toulon in 1793, which had the following dimensions – Tonnage, 2,747 tons, length, 208·33 ft, breadth, 54·83 ft, depth of hold, 25 ft. Armament —Lower deck, thirty-four 32-prs, middle deck, thirty-four 24-prs.; main deck, thirty-four 12-prs.; quarter-deck, fourteen 12-prs, forecastle, four 12-prs Her complement was 1,100 men Inv 1876–1363

92. ENGRAVING OF A FLEET IN LEGHORN ROADS, 1794.

This contemporary engraving by Gio Bougean represents the Spanish fleet anchored in Leghorn Roads under the command of His Excellency Sig Don Giovanni Langara, on the occasion of the reception on board on the 29th April, 1794, of the Prince of Parma

The ships are numbered on the flags at the main trucks and lists of names and captains are shown at the foot of the engraving Inv 1921–1023.

93. RIGGED MODEL OF "LE VENGEUR." (Scale 1 : 64)

This represents a French 74-gun line-of-battle ship sunk off Brest in Lord Howe's action, 1st June, 1794 The model was made of bone by prisoners-of-war confined in Porchester Castle in 1798

The armament was —Lower deck, twenty-eight 36-pr guns, main deck thirty 18-pr guns, quarter-deck and forecastle, sixteen 8-pr guns Her complement was 690 men

Tonnage, 1,750 tons, length, 170 ft, breadth, 44·5 ft, depth of hold, 22 ft, draught, 21 5 ft

Weight of hull and masts, 1,437 tons, total weight of ship and stores for a six months' cruise, 3,548 tons Inv 1881–35, S M 314.

94. LITHOGRAPH OF "LE VENGEUR"

This lithograph after a painting by M A Mayer represents Lord Howe's action, 1st June, 1794, with the French It shows "Le Vengeur," a French 74-gun line-of-battle ship on fire after an action of three hours

"Le Vengeur's" crew were saved by the boats of H M S "Alfred," "Culloden" and "Rattler," the ship sinking a few minutes afterwards.

Inv. 1921–1019

95. RIGGED MODEL OF ENGLISH 64-GUN SHIP. (Scale 1 : 300.) Lent by Count Watson-Howen of Ilanzhowen, 1897

This represents a two-decked line-of-battle ship of the third rate of about 1800, and of about the following dimensions —Tonnage, 1,384 tons, length, 160 ft; breadth, 44·5 ft; depth, 19 ft.

Armament.—Lower deck, twenty-four 32-prs, main deck, twenty-four 24-prs., quarter-deck, twelve 12-prs., forecastle, four 12-prs Complement, 470 men. Inv 1897–107.

96. LITHOGRAPH OF "LES DROITS DE L'HOMME."

This lithograph, after a painting by M. A. Mayer, represents the action between "Les Droits de l'Homme," a French 74-gun line-of-battle ship, and H.M S "Indefatigable" and "Amazon," frigates of 44 and 36 guns respectively on the 13th and 14th January, 1797.

The fight lasted for 12 hours, the ships, due to the bad weather, being then in the Bay of Audierne with a lee shore.

The "Amazon" grounded and shortly afterwards the "Droits de l'Homme" struck on a sandbank opposite the Town of Plouzenec.

The "Amazon's" crew made rafts, reached the shore, and were made prisoners. The survivors of the "Droits de l'Homme" were rescued by the French man-of-war brig "Arrogante" and the cutter "Aiguille."

Inv. 1921–1017

97. HALF MODEL OF THE "SALVADOR DEL MUNDI" (Scale 1 . 48) Presented by the Admiralty, 1920.

This three-decked 112-gun ship was captured from the Spaniards in 1797; and was broken up at Plymouth in 1815

Her armament consisted of thirty 32-prs, thirty-two 24-prs, thirty-two 12-prs and eighteen 9-prs

Tonnage, 2,398 tons, length, 190·75 ft., breadth, 54 3 ft., depth, 23·1 ft

Inv 1920–203

98. SHEER DRAUGHT OF H.M.S. "ENDYMION." (Scale 1 : 48) Presented by H Y. Powell, Esq., 1886.

This shows the complete lines of this frigate, built in 1797 from the lines of the French frigate "Pomone" The "Endymion" was considered to be one of the fastest vessels in the navy during the reign of George III, and was broken up in 1800

Armament Although rated as a 40-gun ship, she frequently carried 46, arranged as follows – Main deck, twenty-six 24-prs, quarter-deck, eighteen 32-pr carronades, forecastle, two 9-prs Her complement was 320 to 350 men

Displacement, for foreign service, 1,695 tons; displacement, for home service, 1,594 tons, length on lower deck, 159 25 ft, length of keel, 132 3 ft; breadth, extreme, 42 ft, breadth, moulded, 41 3 ft, depth of hold, 12·3 ft, area of midship section, 510 sq ft

Inv 1886–107

99. RIGGED MODEL OF H M S "AJAX." (Scale 1 : 24.) Presented by Admiral the Earl of Hardwicke, R N, F R S, 1865.

This represents a 74-gun line-of-battle ship laid down at Messrs Randall's yard, Rotherhithe, in 1795, and launched in 1798 She took part in the battle of Trafalgar, 1805, and was accidentally burnt near the Dardanelles two years later, when forming one of Sir J Duckworth's squadron for forcing that channel The model was constructed by Sir Joseph Sydney Yorke, Bart, between the years 1797–1808

Her armament was –Lower deck, twenty-eight 32-prs, main deck, thirty 24-prs, quarter-deck, fourteen 9-prs, forecastle, two 9-prs Her complement was 540 men

Tonnage, 1,953 tons, length, 182 25 ft., breadth, 49 25 ft, depth of hold, 21 25 ft

Inv 1865–37, 16,174

100. ENGRAVING OF THE BRITISH FLEET IN THE MEDITERRANEAN (1798).

This contemporary engraving, after a painting by Omobuono Roselli represents a British Mediterranean Squadron under the command of Rear-Admiral Sir Horatio Nelson sailing in the vicinity of the port of Leghorn in 1798

Though showing vessels of the period, this print does not accurately represent the fleet referred to, which it is interesting to note was searching for the French fleet, eventually finding and defeating it at the Battle of the Nile, August 1st, 1798

Inv 1921–1022.

101. PRINTS OF THE BATTLE OF THE NILE.

These four engravings represent different phases of the Battle of the Nile, fought in Aboukir Bay between the British and French fleets in August, 1798

The British fleet was commanded by Rear-Admiral Nelson, whose flagship the "Vanguard" is shown, in addition to other vessels

Inv. 1915–70 A, B, C, D.

102. HALF MODEL OF H.M.S. "PORT MAHON." (Scale 1 : 48.) Presented by the Admiralty, 1920.

This 18-gun brig was found building when Port Mahon, Minorca, surrendered in 1798. She was launched in 1799 and broken up at Woolwich in 1837 Her armament consisted of eighteen 18-prs.

She was employed as the Police Ship in the Thames from 1817 until 1837

Tonnage, 277 tons, length, 91·5 ft, breadth, 25·1 ft, depth, 12 7 ft; complement, 70 men. Inv 1920–208.

103. HALF MODEL OF THE "L'EGYPTIENNE." (Scale 1 : 48.) Presented by the Admiralty, 1920.

This 48-gun frigate was captured from the French in the harbour of Alexandria in 1801, and was sold in April, 1817

Her armament consisted of twenty-eight 24-prs, four 9-prs, and sixteen 32-pr carronades.

Tonnage, 1,430 tons, length, 170·1 ft, breadth, 43·6 ft, depth, 15 5 ft, complement, 330 men Inv 1920–212

104. BUILT MODEL OF ARMED CUTTER (Scale 1 . 16)

This is a shipbuilder's model representing the lines and details of the planking of a small armed cutter of the period 1775–1825 The vessel had a full body forward, with a sharp clean run aft, leaving practically no parallel length amidships, and was an extreme example of a general form which was popular with builders of fast sailing craft before 1845, the lines of the model also bear a close resemblance to those of the Southampton fishing "hoys" famous about 1820 for excellent sailing and sea-going qualities

Her armament probably consisted of from six to ten light guns or swivels, and her principal dimensions would be —Tonnage (b o m) 45 tons, length, on deck, 41 ft, breadth, extreme, 17 5 ft, draught, mean, 9 ft Inv 1913–190

105. RIGGED MODEL OF 74-GUN SHIP (1800) (Scale 1 . 144) Lent by E. Gwydyr Jones, Esq., 1923

This model was made by French prisoners-of-war at Portsmouth during the Napoleonic wars for Commander Charles Jones (*a*), R N, grandfather of the lender

It represents a third-rate line-of-battle ship of 74 guns with a complement of about 600 men

A typical armament of a vessel of this class would be —Lower deck, twenty-eight 32-prs, main deck, thirty 24-prs, forecastle and quarter-deck, sixteen 9-prs, and possibly a number of carronades not included in the rated armament

Tonnage, 1,775 tons, length of gun deck, 171 ft, length on keel, 139 ft, breadth, 49 ft, depth of hold, 21 ft Inv 1923 21, S M 1907

106. HALF MODEL OF "L'ÉPERVIER" (Scale 1 · 48) Presented by the Admiralty, 1920

This 16-gun brig was captured from the French in 1803 and was broken up at Pembroke in 1814.

Her armament consisted of sixteen 6-prs, and her complement of 121 men

Tonnage, 315 tons, length, 95·1 ft, breadth, 28 5 ft; depth, 8 8 ft Inv 1920–206

107. RIGGED MODEL OF H.M.S. "ARMIDE." (Scale 1 : 120.) Lent by The Executrices of the late Mrs. B J. Colvin, 1911.

This represents the 40-gun frigate "Armide," built probably about 1800, she was captured from the French, with three similar vessels, off Rochefort in 1806, and added to the British Navy without changing her name.

In the above action she carried 44 guns; long 18-pr guns on the main deck and long 8 pr with 36-pr. carronades on the quarter deck and forecastle

Her burden was 1,104 tons—practically the same as British 50-gun frigates —and her approximate dimensions were —Length, 154 ft, breadth, 40 ft Inv. 1911 111

19th CENTURY SAILING SHIPS-OF-WAR.

Although the employment of the sailing ship-of-war did not continue beyond the middle of this century, considerable improvements were effected in this period, prior to the general introduction of steam propulsion about 1848.

Important structural changes were due to Sir Robert Seppings who was the Surveyor of the Navy from 1813 to 1832. With the additional stresses, consequent on increased length and heavier armament, considerable difficulty was found in preventing the various parts of a wooden ship from "working." When the middle portion of a ship is on the crest of a wave the ends may not be fully supported and will have a tendency to droop. The strains thus set up are known as "hogging" strains and the upper part of the structure is in a state of tension while the lower part is subject to compression. Conversely if the middle of the ship is over a trough of the wave and the ends rest on crests, the middle will sag and the sagging stresses will put the upper part in compression and the lower in extension. These alternating stresses caused the transverse frames to approach and to recede from one another To prevent this, Seppings in 1806–11 introduced "fillings" of solid timber between the transverse frames at the lower part of the ship He further increased the longitudinal strength by continuous "shelf" pieces and thick "waterways" respectively, below and above the beam ends. At a later date he introduced a system of diagonal trussing and bracing of the frame timbers, shown in Nos **128** and **138.** By this means the requisite strength was obtained with considerably less weight than in earlier methods. Sepping also improved the shapes of the bow and stern The square beakhead bow of the 16th and 17th centuries survived throughout the 18th though it was not built to give adequate protection, as revealed, notably, in the condition of H M S. "Victory" after the Battle of Trafalgar. In this case although the largest shot had not always penetrated the round and solid part of the bow, the bow bulkhead was not sufficient to resist even grape shot. The previous rounding of the bow below was consequently continued upward to the gunwale and the square beakhead disappeared This change allowed for an increased armament of the bow whereby several guns could be fired in lines parallel with the keel.

The old square stern was altered to a rounded form, which allowed for improved methods of construction and also enabled the guns to be so mounted that there was no "dead" point.

Sir William Symonds was appointed Surveyor of the Royal Navy in 1832, at which time the restrictions of dimensions according to fixed establishments were removed and the designer was given more liberty. As a result he made his vessels comparatively broader than their predecessors and also employed finer lines and more angular sections below the water line. A series of experimental sailing trials were carried out between 1835 and 1846 which showed the advantages of his design, but although his vessels generally had more speed and were more seaworthy than their rivals they displayed a tendency to pitch and to roll deeply under certain conditions. There are a number of models of "Symondites" in the Museum Collection, a striking feature of which is the "peg-top" section.

Bouger, in 1746, published the first investigations showing the use of the "metacentre" in determining a vessel's stability, while

Bernoiulli in 1757 and Euler in 1759 published treatises on the laws relating to the floating body. In 1775 the Swedish Admiral Frederick Chapman made public the result of his long and successful experience, but it was not until after Symonds's regime that the properties of the metacentre were appreciated by the designers of ships for the British Navy. (*See* a series of articles by A. W. Johns commencing July 28th, 1922, in the "Engineer")

108. RIGGED MODEL OF ENGLISH FRIGATE (1801). (Scale 1 : 144.) Bequeathed by C. R. Leighton, Esq., 1921

This model represents the 32-gun frigate "Aeolus," built on the Thames in 1801, from the designs of Sir Wilham Rule The essential rigging details of the period are well represented

The "Aeolus" was one of a class of five frigates built during the same year, but although termed 32-gun frigates, all were, however, constructed to carry, and some subsequently mounted, 42 guns.

Her armament was :—Main deck, twenty-six long 18-prs , upper deck, ten 24-pr carronades and four long 9-prs

Tonnage, 919 tons ; length of gun deck, 144 ft , breadth 37·5 ft., depth, 12·5 ft. ; complement of men, 260. Inv 1921–137, S.M 1850

109. RIGGED MODEL OF H M.S. "HERO." (Scale 1 : 96) Lent by Sir Alan H. Moore, Bart., 1921

This model, which was rigged by Mr. J T Major in 1921, represents H M.S "Hero," a third-rate line-of-battle ship of 74 guns, built on the Thames by Perry & Co , in 1803.

After taking part in many actions, she was finally wrecked off the Texel in December, 1811.

The armament consisted of :—Lower deck, thirty 32-prs , main deck, twenty-eight 32-prs , forecastle and quarter-deck, sixteen 32-pr carronades

Tonnage, 1,730 tons ; length on gun deck, 175 ft ; length of keel, 144 ft , breadth, 47·5 ft ; depth of hold, 20 ft ; complement, 590 men Inv. 1921–566

110. HALF MODEL OF H M S "LIVELY." (Scale 1 · 48) Presented by the Admiralty, 1920.

This 46-gun frigate was designed by Sir Wm. Rule and was laid down at Woolwich Dockyard in 1801 She was launched in 1804 and lost in 1810

Her armament consisted of twenty-eight 18-prs , four 9-prs , and fourteen 32-pr. carronades.

Tonnage, 1,076 tons , length, 154·1 ft ; breadth, 39 5 ft , depth, 13·5 ft , complement, 284 men. Inv 1920–166

111. HALF MODEL OF H M S "IMPERIEUSE." (Scale 1 : 48.) Presented by the Admiralty, 1920.

This 38-gun frigate was captured when named the "Medea" from the Spaniards on October 5th, 1804, off Cape Santa Maria

Her armament as a British ship was —Main deck, thirty 18-prs , forecastle and quarter-deck, twelve 8-prs Her complement was 300 men

Tonnage, 1,046 tons , length of gun deck, 147 ft , length of keel, 122 ft., breadth, 40 ft. ; depth in hold, 14 ft. Inv 1920–207.

112. HALF MODEL OF H.M S. "BARBADOES" (Scale 1 . 48.) Presented by the Admiralty, 1920.

This 36-gun frigate was captured as a French privateer, "Le Brave," in 1804, and presented to the Royal Navy by the inhabitants of Barbadoes after which place she was renamed. She was wrecked in 1812.

Her armament consisted of twenty-four 9-prs , two 6-prs , and ten 24-pr carronades ; and her complement was 195 men.

Tonnage, 800 tons ; length, 140 ft. ; breadth, 36·6 ft , depth 16 ft Inv. 1920–214

113. WHOLE MODEL OF 14-GUN SLOOP-OF-WAR. (Scale 1 : 48.) Presented by Mrs. Pickering Thompson, 1912.

This model of a ship-rigged sloop-of-war belonged to Admiral T. Pickering Thompson, R.N. (1810-92) and to his father, Admiral John Thompson, R.N., who commanded H.M.S. "Fly" in 1806 and subsequent years, during active operations on the North and South American, Cape of Good Hope, French and Dutch coasts. The model is supposed to represent this vessel

It should be noted that the square transom stern, exhibited by this model, was not a usual feature of vessels of this date and class.

The sloop "Fly" was built at Bursledon, Hants., in 1804, and carried an armament of 16 carronades with two 6-pr. guns. Her other particulars were - Burden, 369 tons, length, overall, 106 ft., length, gun deck, 87·5 ft; breadth, 28·2 ft., depth, 13·9 ft Inv. 1912-136.

114. HALF MODEL OF THE "ALGÉSIRAS." (Scale 1 : 48) Presented by the Admiralty, 1920.

This French line-of-battle ship of 74-guns was captured at the Battle of Trafalgar, 1805, and recaptured by the French the same day.

She surrendered to the Spanish forces at Cadiz on the 9th June, 1808

Tonnage, 1,891 tons, length of gun deck, 181 ft., length of keel, 146 ft., breadth, 49 ft; depth of hold, 22 ft Her complement was 690 men Inv 1920-228

115. RIGGED MODEL OF FRENCH 120-GUN SHIP. (Scale 1 . 240) Lent by Cecil C Fry, Esq, 1913.

This model was made by French prisoners-of-war, and presented to Mrs Elizabeth Fry, the prison reformer

The name "L'Argus" appears on the stern of the model, which represents one of the large first-rates of the period 1807-14, probably a similar vessel to the "Commerce de Marseilles," a 120-gun line-of-battle ship

The armament carried by this class of vessel was - Lower deck, thirty-four 32-prs, middle deck, thirty-four 24 prs, main deck, thirty-four 12-prs, quarter deck, fourteen 12-prs, forecastle, four 12-prs The complement was 1,100 men

Tonnage, 2,747 tons, length, 208·3 ft, breadth, 54 8 ft, depth of hold, 25 ft Inv 1913-462

116. HALF MODEL OF H.M.S "CADMUS" (Scale 1 . 48) Presented by the Admiralty, 1920

This 10-gun brig was designed by Mr Henry Peake, and built by contract, by Mr. Dudman She was laid down in December, 1807, and launched in February, 1808 In 1864, after service as a coastguard vessel, she was sold for £500

There were also built on the same lines the "Cherokee," in the River Thames in 1808, and the "Jasper" at Ipswich in the same year

Her armament consisted of eight 18-pr carronades and two 6-prs The complement was 76 men

Tonnage, 237 tons, length, 90·3 ft, breadth, 24·5 ft, depth, 11 ft Inv. 1920-235.

117. RIGGED MODEL OF H.M.S "CALEDONIA." (Scale 1 : 72.) Lent by R F. Harvey, Esq, 1888.

This 120-gun three-decked line-of-battle ship, designed by Sir W. Rule, was launched at Devonport in 1808 In 1856 she became the hospital ship at Greenwich, and was renamed the "Dreadnought." When launched, this vessel had a square stern which was afterwards rounded In her time people considered her to be the finest vessel of her class, and she was the favourite ship of Admiral Lord Exmouth.

The model shows fidded royal masts, main and forestays snaked, the lead of the mizzen top-gallant and royal braces to the spanker gaff, fore and main belly stays, double martingale, three spritsail yards, the boat stowed in the waist, etc The eight davits in the waist and on the quarters are probably modern additions to the model

Her armament was :—Lower deck, thirty-two 32-prs. ; middle deck, thirty-four 24-prs. ; main deck, thirty-four 18-prs. ; quarter-deck, sixteen 12-prs. ; forecastle, four 12-prs. Her complement was 875 officers and men.

Tonnage, 2,616 tons ; length, on gun deck, 205 ft. ; breadth, 54·5 ft. ; depth of hold, 23·1 ft. Inv 1888–299.

118. WHOLE MODEL (Scale 1 : 288) AND DRAWING (Scale 1 : 48) OF THE "DUKE OF KENT" Presented by John Scott Tucker, Esq., 1865.

This proposed four-decked line-of-battle ship to mount 170 guns was designed by the late Mr Joseph Tucker, Surveyor of the Navy, 1813–31 The design prepared in 1809, contained the following improvements, many of which were afterwards adopted by Sir W Symonds, viz A round bow, an oval or elliptical stern ; hawseholes in the middle deck ; quarter ports for guns on each deck ; vertical stern post, round rudder head, reduced rake of stern, a greater proportional breadth of beam, greater rise in floor timbers, greater elevation of ports from water line ; greater height between decks, greater weight of armament

Proposed armament.—Lower deck, thirty-six 32-prs , lower middle deck, thirty-six 32-prs , middle deck, thirty-six 24-prs , upper deck, thirty-eight 18-prs ; quarter-deck, ten 12-prs and six 32-pr carronades, forecastle, four 12-prs. and four 32-pr. carronades

The model of this proposed vessel has its lower masts and bowsprit stepped and a midship transverse frame (scale 1 24) is also shown

The leading dimensions of the proposed ship were —Burden, 3,700 tons ; length of gun-deck, 221·5 ft , length of keel for tonnage, 178 7 ft , breadth, extreme, 62·4 ft , breadth, moulded, 61·6 ft , depth of hold, 26 ft Inv 1865-17, 18, and 26.

119. RIGGED MODEL OF ENGLISH FRIGATE. (Scale 1 : 128)

This rigged model represents an English 50-gun frigate of about 1800–20. The dimensions would be, approximately —(b o m) 1,100 tons , length of gun deck, 159 ft , length of keel, 130 ft , breadth, 39 ft , depth, 15 ft.

The typical armament of such a vessel would be —Main deck, twenty-eight 18-prs. , quarter-deck, two 9-prs , and twelve 32-pr carronades , forecastle, four 9-prs , and two 32-pr carronades. Ship's complement, 350 men Inv. 1912–95.

120. RIGGED MODEL OF ENGLISH FRIGATE (Scale 1 144) Presented by Miss A M. Jarrett, 1921

This model represents a flush decked vessel, pierced for 48 guns, of the early part of the 19th century

Her armament would probably be —Main deck, twenty-six 24-prs , upper deck, two 9-prs and twenty 24-pr carronades. Complement, about 200 men

The masts and rigging do not appear to be accurately represented to scale and the dimensions taken from the model were approximately —Tonnage, 660 tons , length, on gun deck, 115·5 ft , breadth, 36 ft , depth, in hold, 12 ft Inv 1921–15

121. HALF MODEL OF H.M.S. "ANDROMEDA" (Scale 1 . 48) Presented by the Admiralty, 1920.

This vessel, as the American merchant ship "Hannibal," was built in Maryland in 1810 She was captured by the British in 1812, and renamed "Andromeda" In 1816 she was sold

Her armament consisted of twenty-two 32-pr carronades and two 12-prs. Her complement was 195 men

Tonnage, 812 tons , length, 129·6 ft ; breadth, 37 5 ft , depth, 11 ft Inv 1920–210

122. WHOLE MODEL OF ENGLISH FRIGATE. (Scale 1 : 48)

This represents a 50-gun vessel specially designed in 1813 to cope with the more powerful frigates then being introduced abroad.

Her armament was:—Main deck, thirty 24-prs.; quarter-deck, sixteen 42-pr. carronades; forecastle, two 42-pr. carronades and two 24-prs. Her complement was 480 men.

Her dimensions were approximately:—Tonnage, 1,458 tons; length, 172 ft., breadth, 44 ft., depth of hold, 14 ft. Inv. 1881–32

123. HALF MODEL OF H.M.S. "FLORIDA." (Scale 1 : 48.) Presented by the Admiralty, 1920.

This 20-gun sloop was built as the "Frolic," at Charleston in 1813, and was captured from the Americans the following year. She was renamed "Florida," and was broken up at Chatham in 1819.

The armament consisted of eighteen 32-pr. carronades and two 9-prs., and her complement was 135 men.

Tonnage, 539 tons, length of gun deck, 119·6 ft., breadth, 32 ft.; depth, 14·2 ft Inv. 1920–200

124. HALF MODEL OF H.M.S. "EDEN." (Scale 1 : 48.) Presented by the Admiralty, 1920.

This 28-gun sloop, designed by Sir W. Rule, was built by contract by Mr Courtney at Chester in 1813–14. She was broken up at Portsmouth in 1833.

There were also built on the same lines the "Mersey" at Chester in 1814, and the "Tyne" at Topsham in 1814

The armament consisted of eighteen 32-pr. carronades, eight 12-prs. and two 6-prs; and her complement of men was 150

Tonnage, 451 tons, length, 108·5 ft., breadth, 30·7 ft., depth, 9 ft Inv. 1920–238

125. RIGGED MODEL OF H.M.S. "ARIADNE." (Scale 1 . 24.) Presented by Sir D. H. Macfarlane, 1883

This sailing frigate was built at Portsmouth in 1816, and sold out of the service in 1841. The model is believed to have been constructed and rigged under the supervision of Captain Marryat (the novelist), who commanded the vessel in 1828–30. It shows the main deck with its complete battery, the flush upper deck with its hammock nettings, and 20 carronades, these small guns were not, however, counted in a ship's armament until 1817

Armament:—Main deck, twenty 32-prs, six 18-prs, and two 9-prs, upper deck, twenty 32-pr carronades Complement, about 180 men

Tonnage, 511 tons, length, 121·6 ft., breadth, 31 3 ft., depth of hold, 12 ft Inv 1883-43, 26,290

126. RIGGED MODEL OF A REVENUE CUTTER (Scale 1 · 32.)

This belongs to the period 1810–30, and carries 14 guns and 4 swivels

Tonnage, 130 tons, length, 85 ft., breadth, 24 ft., depth, 13·3 ft., draught, 11 ft Inv 1877-417 S.M. 1925

127. WHOLE MODEL OF ENGLISH FRIGATE (1820). (Scale 1 64.) Presented by William E. Allum, Esq., 1922

This model was built by John Pratt, shipwright of Deptford Dockyard who was the grandfather of the donor It represents a 50-gun frigate of about 1820.

Although shown pierced for 58 guns, the normal armament of this class rarely exceeded 50 guns. Portion of the upper deck planking has been omitted to render the interior visible.

Tonnage, 1,580 tons; length, 156 ft., breadth, 48 ft; depth of hold, 12 ft. Inv. 1922–50, S.M. 1570.

128. SECTIONAL MODEL OF SECOND-RATE LINE-OF-BATTLE SHIP (Scale 1 · 32.) Presented by the Admiralty, 1922.

This represents a longitudinal section of an English second-rate line-of-battle ship illustrating important structural features introduced by Sir Robert Seppings in the early part of the 10th century.

The features include the " trussed frame," which consists of a combination of timbers or riders, longitudinals, and trusses. The first are in three lengths, arranged diagonally, and extending from the limber to the shelf of the lower gun-deck. The longitudinals and trusses are so placed that their abutments are in close contact with the riders, the whole being firmly united with the frame timbers and outside planking.

Sir Robert Seppings was responsible for several other important improvements in English ship construction, namely :—The filling in of the spaces between the frame timbers; shelf pieces and water ways for ship's side connections of beams; the diagonal arrangement of deck planking; the introduction of the round bow and the rounded stern. Some of these features appear, however, to have been used at an earlier date in foreign practice. Inv. 1922–437.

129. MODEL OF SQUARE AND CIRCULAR STERNS. (Scale 1 : 16.) Presented by the Admiralty, 1920.

These two half models illustrate the differences between the square stern of H.M.S. " Canopus," a ship of 84 guns, and the circular stern proposed by Sir Robert Seppings and adopted in a number of vessels built on the lines of the " Canopus," between 1821 and 1832.

The " Canopus " was built as the " Franklin " by the French at Toulon in 1796, and was captured from them in 1798. Inv. 1920–304.

130. MODEL OF STERN OF H.M.S. " HIBERNIA." (Scale 1 : 16.) Presented by the Admiralty, 1920.

This model shows the starboard side of the circular stern of H.M.S. " Hibernia," a line-of-battle ship of three decks, carrying 120 guns.

The vessel was launched at Devonport yard in 1804 with a square stern, but this was subsequently replaced by one, similar to that represented. Inv. 1920–312.

131. RIGGING MODEL OF H.M.S. " GANGES." (Scale 1 : 24.) Presented by Capt H. T. Burgoyne, R.N., 1865.

This was rigged by Capt. Burgoyne, and shows the masts, rigging, and sails of a wooden, two-decked line-of-battle ship of 84 guns. The names of the sails and of the spars are indicated by labels attached to them. The " Ganges " was built at Bombay in 1819–21 from the designs of Sir Robert Seppings. She was last commissioned September 4th, 1857, and paid off May 15th, 1861, being the last sailing line-of-battle ship in H.M. Navy.

Tonnage, 2,285 tons, length, 196·5 ft., breadth, 52·2 ft. Inv. 1865–10.

132. RIGGED MODEL OF 120-GUN SHIP. (Scale 1 · 120.) Lent by H. Edenborough, Esq., 1901.

This represents a line-of-battle ship of the first rate at the commencement of the 19th century, and is of a class of which only four were constructed in England between 1808 and 1827. The model probably represents the " Prince Regent," launched at Chatham in 1823, another of the four was the " Caledonia " (*see* No. **117**).

The rigging of the model is very complete and shows fidded royal masts, snaked fore and main stays, and sprit and sprit topsail yards in position, also the arrangements for working the boats. The whole of the hull of the model is built, and the bottom is coppered, the bow has the square forecastle, which prevailed for many years and was only abandoned when it was discovered that the flat surfaces were penetrated by grape shot more readily than the rounded bow.

The armament was :—Lower deck, thirty-two 32-prs.; middle deck, thirty-four 24-prs., main deck, thirty-four 18-prs.; quarter-deck, sixteen 12-prs.; forecastle, four 12-prs. Complement, 875 men.

Tonnage, 2,602 tons; length on gun deck, 205 ft.; length on keel, 170·9 ft.; breadth, extreme, 58 ft.; depth of hold, 23·16 ft. Inv. 1901–35.

133. WHOLE MODEL OF H.M.S. " PYLADES." (Scale 1 : 48.) Presented by the Admiralty, 1920.

This 18-gun sloop, designed by Sir Robert Seppings, was laid down at Woolwich yard in March, 1823, and was launched in June of the following year. She was broken up in May, 1845.

The armament consisted of sixteen 32-pr. carronades, and two 9-pr. carronades and her complement was 125 men.
Tonnage, 433 tons; length, 100·1 ft.; breadth, 30·3 ft.; depth, 8·1 ft
Inv. 1920-282.

134. HALF MODEL OF H.M.S. "CRUISER" (Scale 1 : 48. Presented by the Admiralty, 1920.

This 18-gun brig was built at Chatham in 1826–28, and sold out of the service at Bombay in 1859 She follows the lines of the "Cruiser" designed by Sir W Rule and launched at Ipswich in 1797, to which design over one hundred vessels were constructed
The "Cruiser," represented by the model, was included in the experimental squadron of 1844–45.
Her armament consisted of sixteen 32-pr. carronades and two 6-prs The complement was 125 men
Tonnage, 384 tons, length, 100 ft, breadth, 31 ft, depth, 12·8 ft
Inv 1920-237

135. RIGGED MODEL OF SERVICE YACHT. (Scale 1 48) Presented by J J. Miller, Esq., 1894.

This represents a class of cutter used by the Admiralty about 1830 for harbour service, as tenders to the flag ships, similar vessels were also used in the Customs service They usually carried a mainsail, foresail, jib, and gaff topsail, also a yard for spreading a square sail when running before the wind The model was rigged in the Museum in 1902
The approximate dimensions were —Tonnage (b o m), 135 tons, length of keel, 68 ft, breadth, 20 ft, depth of hold, 8 ft
Inv 1894 183

136. RIGGED MODEL OF ARMED SCHOONER (Scale 1 · 24)

This built model represents an armed topsail-schooner of about 1830, such as was used as a despatch vessel to a line-of-battle ship or as a patrol and preventative vessel The model was masted and rigged in the Museum in 1914
Her armament was sixteen 12-pr carronades, and the complement, 30 men
Tonnage, 125 tons, length, 75 ft, breadth, 19 5 ft, depth of hold, 9 ft
Inv 1913–652, S M 1060

137. HALF MODEL OF THE "PRUEBA" (Scale 1 48) Presented by the Admiralty, 1920

This Spanish vessel, an ex-38-gun frigate, was captured by H M S "Brisk," a brig of three guns, in 1831 When captured there were 313 slaves on board
Tonnage, 1,080 tons, length of gun deck, 154 ft, length of keel, 127 ft, breadth, 40 ft, depth of hold, 12 ft
Inv 1920 211

138. MODEL OF MIDSHIP SECTION OF H.M S. "RODNEY" (1833) (Scale 1 : 24) Presented by F. W Slade, Esq, 1903

The "Rodney" was a two-decked line-of-battle ship of 92 guns, designed by Sir R Seppings and launched at Pembroke in 1833. The model shows the various decks and the interior of the main hold of the vessel, together with the general arrangements for the stowage of water-tanks and provisions, also the principal features of the system of wooden ship construction followed at the time.
Amongst the structural details represented are some improvements introduced by Sir R. Seppings in 1813–32 while he was Surveyor of the Navy, these include :—
(1) The employment of a system of internal diagonal timber ties, crossing the frames at 45 degs. and fitted between themselves with corresponding struts, the panels thus formed were further stiffened by the insertion of longitudinal timbers, so that the whole arrangement converted the hull into a completely trussed structure By this construction the requisite strength was obtained with considerably less weight than was necessary in the earlier system with its massive vertical riders and internal planking.

(2) The method of connecting the heads and heels of the timbers composing the transverse frames, by plain butts with circular dowels or plugs instead of by the various methods of scarfing previously in use.

(3) The introduction of thick continuous "waterways" and "shelf-pieces," placed respectively above and below the ends of the deck beams, to secure better connection of the beams with the sides of the vessel and also additional longitudinal strength.

Other details shown are:—The use of forked iron knees to the beams; the arrangement of pillars or stanchions for supporting the decks; and the varying thicknesses adopted for different portions of the external planking. A number of the strakes of planking near the waterline are shown cut on the "anchor-stock" system, which gave an increase of structural strength while reducing the waste in preparing the planking from tapered logs. On the orlop deck are shown the rope anchor cables, used before the introduction of chain cables, and in the planking of this relatively important deck can be seen the device by which short pieces of planking were utilised.

The "Rodney" took part in some trials of ships of the line during 1845–46, and proved herself to be superior to her contemporaries in speed and steadiness during rough weather; in 1860 she was converted into an auxiliary screw-ship.

Her original dimensions were:—Tonnage (b.o.m.), 2,626 tons; length, 205·5 ft. breadth, 54·5 ft.; depth, 23·1 ft. Inv. 1903–63.

139. MODEL OF HULL OF H.M.S. "PIQUE." (Scale 1 : 48) Presented by the Admiralty, 1920.

This model represents the condition in which H.M.S. "Pique" was found on being dry-docked at Portsmouth in 1835.

She was a 40-gun frigate designed by Sir Wm. Symonds and built at Devonport in 1834.

She ran ashore on the coast of Labrador on September 22nd, 1835. After being on the rocks for 11 hours the ship's company succeeded in heaving her off into deep water. Although making from 12–24 inches of water per hour it was decided to proceed to England.

On September 27th, during a heavy gale, she lost her rudder, temporary rudders were fitted but were carried away, steering by means of a hawser veered astern she arrived in St. Helens on October 13th, having sailed 1,500 miles rudderless. All pumps were worked for twenty minutes out of every hour for 21 days.

Tonnage, 1,633 tons; length, 160 ft.; breadth, 48 8 ft.; depth, 14·6 ft. Inv. 1920–340.

140. MODELS OF BOW AND STERN OF H.M.S. "PIQUE." (Scale 1 . 24) Presented by the Admiralty, 1920.

H.M.S. "Pique" was a 40-gun frigate, which was designed by Sir Wm. Symonds, and launched at Devonport in 1834.

The models show the bow and also the elliptical stern. Inv. 1920–294, and 302.

141. RIGGED MODEL OF H.M.S. "VANGUARD." (Scale 1 . 48) Plate VII, No. 1, p. 48.

This 80-gun, two-decked vessel, built at Pembroke in 1835, was the first line-of-battle ship constructed from the designs of Sir W. Symonds.

Owing to the removal of some of the limitations that had been placed upon the dimensions of vessels of the various rates, the "Vanguard" was made broader in proportion to her length than any of her predecessors, and was also given finer lines and more angular sections below the water-line. The special features are, however, more clearly illustrated by the adjacent models of the "Albion" and the "Fantôme," by the same designer. She took part in the experimental trips of H.M. ships in 1836–46, and showed comparatively good speed and handiness under sail, but had a tendency to pitch in a head sea and to roll deeply when before the wind.

The model is built throughout and copper fastened, it was rigged in the Museum in 1903 in accordance with the table of standard dimensions for masts and yards prepared by Sir W. Symonds. Adjacent to it is represented the temporary cradle and ground-ways used in launching such a vessel.

The " Vanguard " carried 650 men, and her armament consisted of : Lower-deck, twenty 32-prs. and eight 8-in guns ; main deck, twenty-four 32-prs. and four 8-in. guns ; quarter-deck and forecastle, twenty-four 32-prs.

Tonnage (b.o.m.), 2,609 tons ; length on lower deck, 190 ft. ; breadth, extreme, 57 ft. Inv. 1889–83, 27,678.

142. HALF MODEL OF H.M.S. " BONETTA." (Scale 1 : 48.) Presented by the Admiralty, 1920.

This 3-gun brigantine was designed by Sir Wm. Symonds, and was built at Sheerness Dockyard in 1834–36. During her service she was engaged in the suppression of the slave trade off the West Coast of Africa, and in 1861 she was broken up at Deptford

There were also built on the same lines, the " Dolphin," at Sheerness in 1836 ; the " Spy," at Sheerness in 1841, and the " Dart," at Sheerness in 1847

Her armament consisted of two 32-pr 25-cwt guns, and one 32-pr 40-cwt gun. Her complement of men was 70

Tonnage, 319 tons , length, 90·7 ft. , breadth, 29·3 ft. ; depth, 14·6 ft Inv 1920–230

143. MODEL OF STERN OF H.M.S. " INCONSTANT " (Scale 1 : 24) Presented by the Admiralty, 1920.

This represents the elliptical stern of H.M.S. " Inconstant," a 36-gun frigate launched at Portsmouth Yard in 1836, the vessel's design having been prepared by Admiral Hayes. Inv. 1920–301

144. LITHOGRAPH OF " L'ARETHUSE "

This lithograph, after a painting by M. H. Durand Brager, represents the French 32-gun frigate " L'Arethuse " anchored, with her crew's hammocks drying after being washed

The dimensions of this class as laid down in the Establishment of 1837 were : Displacement, 999 tons ; length on gun deck, 138 6 ft. , moulded breadth, 36 ft , mean draught, 15·5 ft Inv. 1921 1016

145. HALF MODEL OF H.M.S. " PILOT." (Scale 1 : 48) Presented by the Admiralty, 1920

This 16-gun brig was designed by Sir Wm. Symonds, and built at Devonport Yard in 1837–38 She was sold out of the service in January, 1862.

Her armament consisted of twelve 32-pr 17-cwt carronades and four 32-pr 25-cwt guns The complement was 130 men

Tonnage, 485 tons , length, 105 ft ; breadth, 33 5 ft , depth, 14 8 ft Inv. 1920–234

146. HALF MODEL OF H.M.S. " DAPHNE." (Scale 1 . 48.) Presented by the Admiralty, 1920

This 18-gun sloop, designed by Sir Wm. Symonds, was laid down at Pembroke Yard in December, 1835, and launched in August, 1838 The " Dido " was built on the same lines in 1836

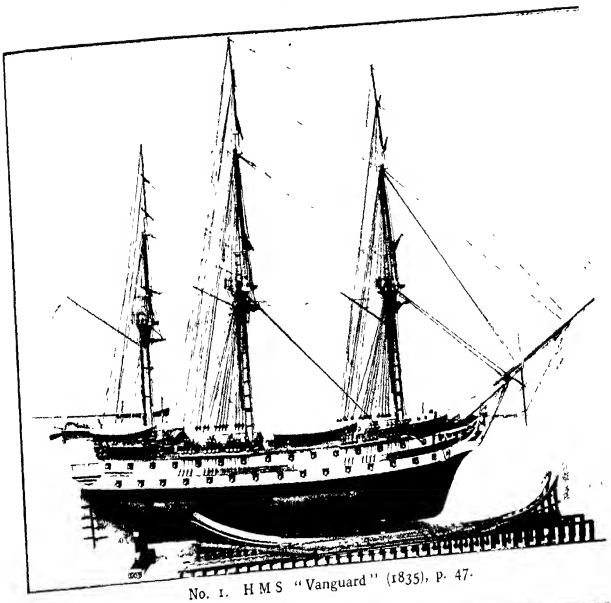
The armament consisted of eighteen 32-pr. 40-cwt guns, and the complement, 148 men

Tonnage, 726 tons , length, 120 ft , breadth, 37·7 ft ; depth, 18 ft Inv. 1920–249.

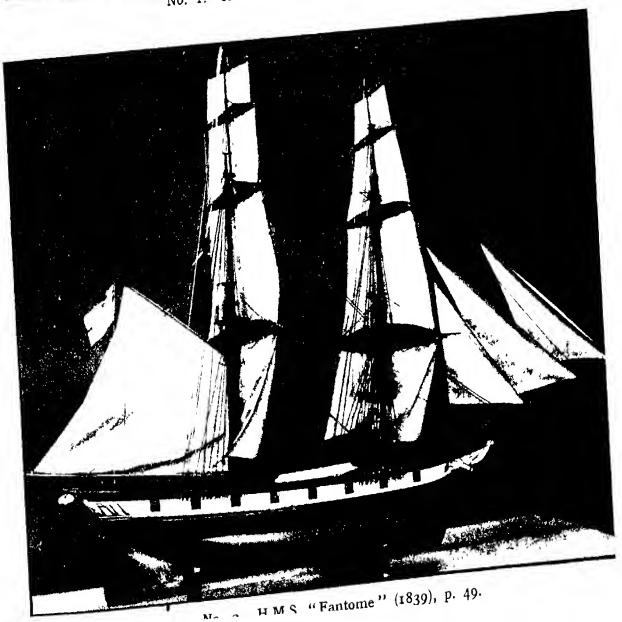
147. HALF MODEL OF " LE JEMMAPES." (Scale 1 : 48.) Presented by the Admiralty, 1920.

This represents a French line-of-battle ship of 106 guns, which was launched in 1840.

Displacement, 4,374 tons ; length on water line, 204·3 ft. ; breadth, 53·2 ft. ; depth of hold, 24 ft. Inv. 1920–205.



No. 1. H M S "Vanguard" (1835), p. 47.



No. 2. H M S "Fantome" (1839), p. 49.

148. HALF MODEL OF H.M.S. "SPARTAN." (Scale 1 : 48.) Presented by the Admiralty, 1920.

This 26-gun frigate was designed by Sir Wm. Symonds, and was laid down at Devonport Yard in June, 1838. She was launched in August, 1841, and sold out of the service in May, 1862

Her armament consisted of eighteen 32-pr. 40-cwt. guns, two 8-in 50-cwt guns, and six 32-pr. 25-cwt guns. The complement of men was 240.

Tonnage, 918 tons, length, 131 ft, breadth, 40·6 ft, depth, 10·7 ft.
Inv 1920-248.

149. RIGGED MODEL OF H.M.S "FANTÔME." (Scale 1 · 39.) Plate VII, No. 2, p. 48.

This brig-rigged sloop-of-war was launched at Chatham in 1839, and sold out of the Navy in 1865 She was designed by Sir William Symonds, who gave her the finer lines and steeper floors which he introduced into the underwater form of British war vessels At about the same time 13 similar war brigs were also constructed

This model was masted and rigged in the Museum in 1902-03, the masts, yards, etc, being made in accordance with the dimensions established by Sir W Symonds in 1836

The armament of the "Fantôme" consisted of four 32-prs and twelve 32-pr carronades, and her complement was 130 men.

Tonnage (b o m), 485 tons; length, on deck, 105 ft, breadth, extreme, 33 5 ft, depth, 14·8 ft. Inv 1888-243, 27,120

150. LITHOGRAPH OF H.M.S "ST GEORGE"

This lithograph by T G Dutton from a painting by W H Harvey, R N., represents the sailing three-decker "St George" of 120 guns, as commissioned for service with the Baltic Fleet in the operations against Russia in 1854

The vessel was built of wood at Devonport about 1840 from the designs of Sir W Rule and had the following dimensions --Burden, 2,710 tons, length, gun deck, 206 ft, breadth, 54·6 ft; depth, 23 ft

In 1859 she was converted to a screw-propelled two-decker carrying, at first, 91 guns and afterwards 72 guns She was removed from active service in 1869.
Inv 1910-202.

151. HALF MODEL OF H M S "SIREN" (Scale 1 48) Presented by the Admiralty, 1920.

This 10-gun sloop was designed by Sir Wm Symonds and built at Woolwich Yard in 1839-41

There were also built on the same lines, the "Helena" at Pembroke in 1843, the "Jumna" at Bombay in 1848, and the "Atalanta" at Pembroke in 1847

The armament consisted of sixteen 32-pr 25-cwt guns, and the complement of 130 men

Tonnage, 549 tons; length, 110 ft, breadth, 34 8 ft, depth, 14·8 ft
Inv 1920-230.

152. HALF MODEL OF H M.S. "SUPERB." (Scale 1 : 48) Presented by the Admiralty, 1920

This 80-gun ship, designed by Sir Wm Symonds, was laid down at Pembroke Yard in 1838 and launched in 1842

There were also built on the same lines the "Collingwood" at Pembroke in 1841, the "Colossus," at Pembroke in 1848, the "Lion" at Pembroke in 1847, the "Centurion" in Pembroke in 1844, and the "Meeanee" at Bombay in 1848

Her armament consisted of --Lower deck, twenty 32-pr 56-cwt guns and eight 8-in 65-cwt guns, main deck twenty-four 32-pr 50-cwt guns, four 8-in 65-cwt guns; and upper deck, twenty-four 32-pr 41-cwt guns The complement was 720 men

Tonnage, 2,583 tons, length, 190 ft, breadth, 57 ft, depth, 23·3 ft
Inv. 1920-161

153. HALF MODEL OF H.M S. "CUMBERLAND." (Scale 1 : 48) Presented by the Admiralty, 1920.

This 70-gun ship, designed by Sir Wm. Symonds, was laid down at Chatham

Yard in 1836, and launched in 1842. She formed part of the Anglo-French fleet in the Baltic in 1854, and in 1889 she was destroyed by fire while in the service of the Clyde Training Ship Association. The "Boscawen" was built on the same lines at Woolwich in 1844.

The armament consisted of sixty-four 32-prs. and six 8-in. guns. Her complement was 600 men.

Tonnage, 2,214 tons length, 180 ft , breadth, 54·2 ft. , depth, 22·3 ft.
Inv. 1920–222.

154. MODELS OF BOW AND STERN OF H.M.S. "CUMBERLAND." (Scale 1 : 24.) Presented by the Admiralty, 1920.

H.M.S. "Cumberland" was a 70-gun ship, designed by Sir Wm Symonds and launched at Chatham Yard in 1842.

One model represents the bow and the other shows the elliptical stern, which illustrates the arrangements for the guns to fire directly aft
Inv. 1920–293 and 299.

155. WHOLE MODEL OF H.M.S. "ALBION." (Scale 1 : 48) Plate VIII, No 2, p 50, and Plate IX, No. 2, p 50.

This was a 90-gun sailing line-of-battle ship, designed by Sir W Symonds, and launched at Devonport in 1842 She took part in the bombardment of Sebastopol in 1854, where she suffered most severely In 1861 she was converted into a screw ship

Her armament was —Lower deck, twenty-eight 32-pr 56-cwt guns and four 68-pr 112-cwt guns, main deck, twenty-six 32-pr 56-cwt guns and six 8-in 65-cwt guns, quarter-deck, sixteen 32-pr 42-cwt guns and two 8-in 52-cwt guns, forecastle, eight 32-pr 42-cwt guns Her complement was 820 men

Tonnage, 3,111 tons, length, 204 ft , breadth, 60 ft , draught, 18·75 ft
Inv 1894 230, 30390, S M 1696

156. FIGURE HEAD OF H.M.S "ALBION" (1842). Presented by Messrs Castle's Shipbreaking Co , Ltd , 1913

This is the original wooden figure head (helmet missing) carried by H M S "Albion," a line-of-battle ship of 90 guns, launched at Devonport in 1842 (*see* adjacent model).
Inv. 1913 199, S M 619, S M 620

157. HALF MODEL OF H.M.S "MUTINE" (Scale 1 48) Presented by the Admiralty, 1920.

This 12-gun brig was designed by Mr Fincham She was laid down at Chatham Yard in October, 1843, launched in April, 1844, and lost in 1848 She was included in the experimental squadron of 1844 45

Her armament consisted of ten 32 pr 25-cwt guns and two 18-pr 20-cwt guns

Tonnage, 428 tons , length, 111 0 ft , breadth, 31 0 ft , depth, 13 6 ft , complement, 130 men
Inv 1920 231

158. HALF MODEL OF H.M.S. "FLYING FISH" (Scale 1 . 48.) Presented by the Admiralty, 1920

This 12-gun brig was designed by Sir Wm Symonds She was built at Pembroke Yard in 1843–44, and broken up at Portsmouth in 1852

She formed part of the squadron of experimental brigs with which a series of famous trials were carried out in 1844–45.

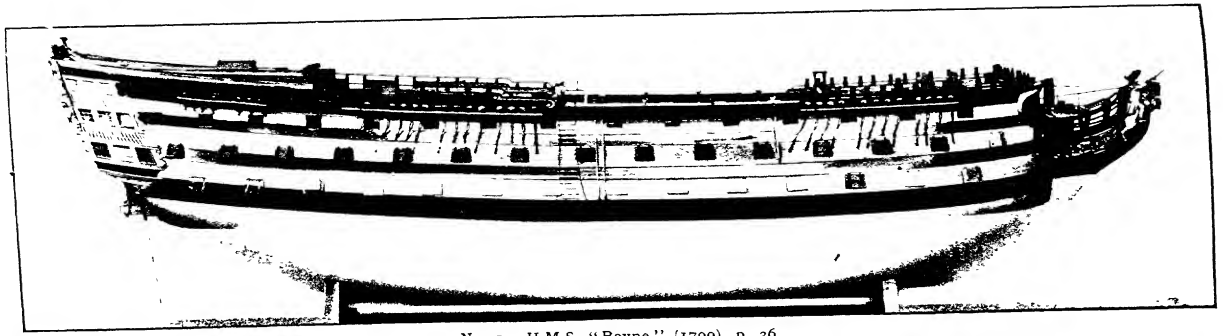
The "Kingfisher" was built on the same lines at Pembroke in 1845

Her armament consisted of ten 32-pr 25-cwt guns and two 18-pr. 20-cwt guns, and her complement was 130 men

Tonnage, 445 tons , length, 103·1 ft ; breadth, 32·4 ft , depth, 14·4 ft
Inv 1920–233

159. HALF MODEL OF H.M.S. "ESPIÈGLE." (Scale 1 . 48.) Presented by the Admiralty, 1920.

This 12-gun brig, which formed part of the experimental squadron (1844–45), was designed by Messrs. Read, Chatfield and Creuze. She was built at Chatham Yard in 1844, and sold in November, 1861, for £805.



No 1. H M S "Boyne" (1790), p. 36.

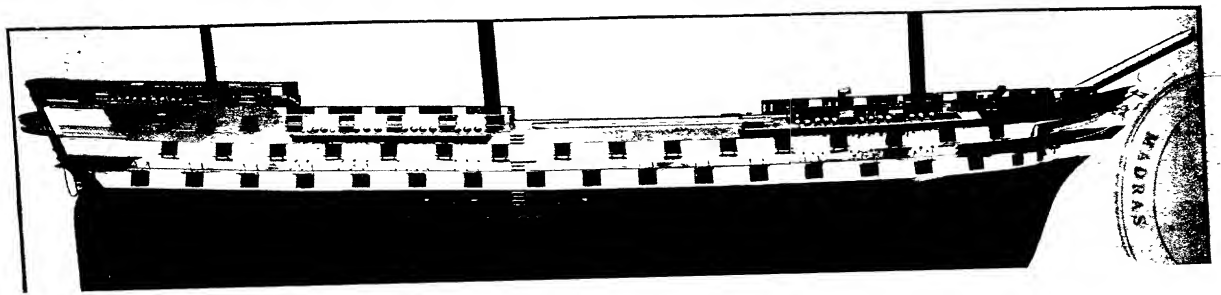
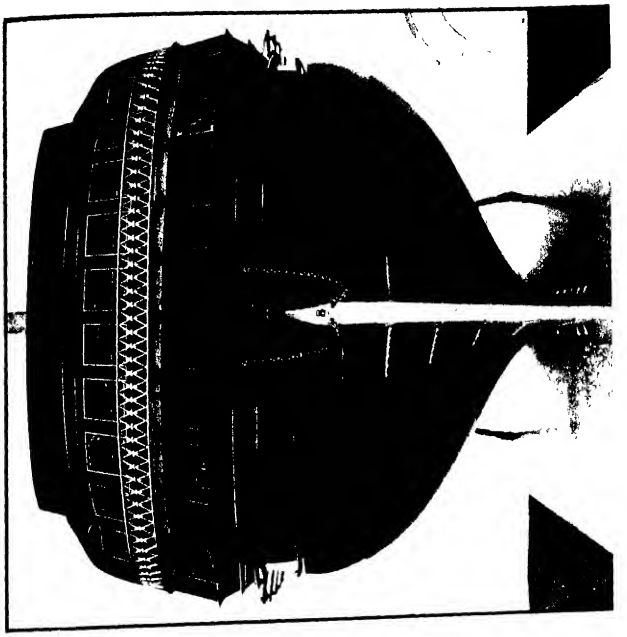
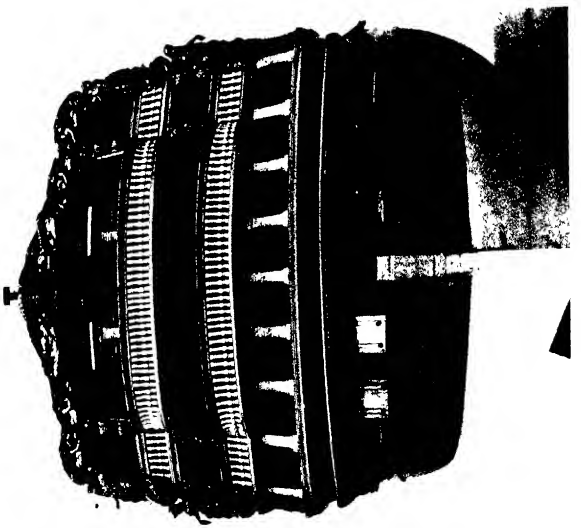


PLATE IX.





Her armament consisted of ten 32-pr. 25-cwt. guns, and two 18-pr. 20-cwt guns, and the complement was 130 men.

Tonnage, 443 tons; length, 104 7 ft, breadth, 31 8 ft.; depth, 13·1 ft.
Inv. 1920–232.

160. MODEL OF STERN OF H.M.S. "ALARM." (Scale 1 24.) Presented by the Admiralty, 1920.

This model represents the elliptical stern of H M S "Alarm," a 26-gun frigate launched at Sheerness in 1845 to the design of Sir Wm Symonds
Inv. 1920–295

161. WHOLE MODELS OF SAILING CORVETTES. (Scale 1 : 48) Contributed by John Scott Russell, F R S, 1868.

These vessels are designed on Mr. Scott Russell's "wave principle," but have the following features advocated by Admiral E G Fishbourne in 1845 as desirable in a sailing ship-of-war —The buttock lines are continuous curves to minimise pitching, with the same object, a fine bow and a full after-body are provided To promote steady steering there is a long run of perpendicular side, a long keel, a lean fore-foot, and a fine heel, while to insure powerful action of the rudder the draught of water is greatest aft; the floor rises aft from the midship section

These principles were adopted for H M S "Warrior" in 1861.

Length on load water-line, 124 or 130 ft, breadth, extreme, 31 ft, depth at side, 16 ft
Inv. 1868–107

162. HALF MODEL OF H M S. "CONSTANCE." (Scale 1 48) Presented by the Admiralty, 1920

This 50-gun frigate was designed by Sir Wm Symonds, and built at Pembroke Yard in 1843–46

There was also built on the same lines the "Arethusa" at Pembroke in 1849, and the "Octavia" at Pembroke in 1849

The armament consisted of ten 8-in 65-cwt guns, twenty-two 32-pr 56-cwt guns, eighteen 32-pr 45-cwt guns Her complement was 500 men

Tonnage, 2,132 tons, length, 180 ft, breadth, 52 8 ft, depth, 16·3 ft

In 1862 the "Constance" was converted at Devonport into a screw frigate of 51 guns and 500 h p, but the model shown and the dimensions given are as she was built for a sailing ship
Inv 1920–168

163. HALF MODEL OF H M S "THETIS" (Scale 1 48.) Presented by the Admiralty, 1920

This 30-gun frigate was designed by Messrs Read, Chatfield and Creuze She was built at Devonport Yard in 1844 46, and in 1855 she was exchanged with the Prussian Government for two gun-boats

During 1847 the "Thetis" took part in a series of trials in which her sailing qualities compared favourably with those of several ships of the line, including the "Vanguard," "Superb" and "Albion."

Her armament consisted of —Main deck, eighteen 32-pr 56-cwt guns, four 8-in 60-cwt guns; upper deck, two 32-pr 50-cwt guns and twelve 32-pr 25-cwt. guns

Tonnage, 1,533 tons, length, 164·6 ft, breadth, 40·7 ft, depth, 13 5 ft, complement, 320 men
Inv 1920–242

164. HALF BLOCK MODEL OF H.M S "RECRUIT." (Scale 1 48)

This 12-gun brig was built of iron in 1846 at Blackwall by Messrs Ditchburn & Mare, and is interesting as being the first iron-built fighting ship constructed for the British Navy

She was designed to compete with a number of wooden brigs of the same rating then under construction, but so strong was the prejudice against the use of iron for war-vessels that the intended trials were never made, and the "Recruit" was eventually sold out of the Service

Although the new material was meanwhile adopted in troopships, floating batteries, etc, it was not till fifteen years later that iron construction became general for battleships.

The principal dimensions were :—Length on keel, 114·4 ft.; breadth, 30·6 ft., draught, 12·5 ft.; tonnage (b.o.m), 462 tons. Inv. 1899-28.

165. HALF MODEL OF H.M.S. "ARACHNE." (Scale 1 : 48.) Presented by the Admiralty, 1920.

This 18-gun sloop was designed by Sir Wm. Symonds and built at Devonport Yard in 1845-47.

Her armament consisted of two 32-pr. 39-cwt. guns, sixteen 32-pr. 25-cwt. guns, and her complement of 145 men

Tonnage, 602 tons; length, 115 ft., breadth, 35·5 ft.; depth, 16·8 ft

The "Terpsichore" was also built on the same lines at Blackwall in 1847 Inv 1920-250

166. HALF MODEL OF "LE VALMY." (Scale 1 . 50.) Presented by the Admiralty, 1920

This 120-gun ship, which was the last three-decker in the French Navy, was built at Brest in 1847 to the designs of M. Leroux

Afterwards she was renamed "Borda" and became a Naval School in Brest Roads

Displacement, 5,154 tons, length on gun deck, 210 ft; breadth, 57 ft, depth, 59 ft, draught, 28 25 ft Inv 1920-204

167. HALF MODEL OF H.M.S. "LEANDER" (Scale 1 . 48) Presented by the Admiralty, 1920.

This 50-gun frigate was designed by Mr Richard Blake, the master-shipwright at Portsmouth Yard, where she was laid down in Februarv, 1845, and launched in 1848

Her armament consisted of ten 8-in 65-cwt guns, twenty-two 22-pr 56-cwt guns, eighteen 32-pr 45-cwt guns, and her complement was 500 men

Tonnage, 1,987 tons, length, 181·4 ft; breadth, 50 7 ft, depth, 15·6 ft.

In 1861 she was converted at Sheerness into a screw frigate of 51 guns and 400 h p, but the model represents her when a sailing ship Inv 1920-241

168. HALF MODEL OF H.M.S. "PHAETON." (Scale 1 : 48) Presented by the Admiralty, 1920.

This 50-gun frigate was designed by Mr J White and was built at Deptford Yard, 1845-48

The armament consisted of ten 8-in 65-cwt guns, twenty-two 32-pr 56-cwt guns, eighteen 32-pr 45-cwt guns Her complement was 500 men

Tonnage, 1,942 tons, length, 184 9 ft, breadth, 48 5 ft, depth, 15 8 ft

She was converted to a screw frigate of 51 guns and 400 h p in 1859 at Sheerness Inv 1920-244

169. HALF MODEL OF H.M.S. "INDEFATIGABLE" (Scale 1 : 48.) Presented by the Admiralty, 1920

This 50-gun frigate was designed by Mr W Edye, and built at Devonport Yard in 1846-48

Her armament consisted of.—Main deck, twenty-eight 8-in 65-cwt guns; upper deck, twenty-two 32-pr 45-cwt. guns The complement was 500 men

Tonnage, 2,047 tons; length, 180 ft, breadth, 51·5 ft; depth, 16 5 ft. Inv. 1920-245

170. MODEL OF STERN OF H.M.S. "NARCISSUS." (Scale 1 : 24.) Presented by the Admiralty, 1920.

This model represents the elliptical stern of the 50-gun frigate "Narcissus," which was designed by the Admiralty, and laid down at Devonport Yard in November, 1849. Inv. 1920-297.

171. HULL OF BRIG. (Scale 1 : 36) Presented by the Admiralty, 1920.

This hull represents a brig of about 1850.

The armament would probably be twelve 32-pr. carronades, and the complement 130 to 150 men.

Approximate dimensions —Tonnage, 350 tons, length of kee, 106 ft.; breadth, 27 ft.; draught, 12 ft. Inv 1920-284.

172. WHOLE MODEL OF AN ARMED SCHOONER. (Scale 1 : 48.)

This represents a small fast schooner, dated about 1850, fitted to carry an armament of 18 light guns.

Her approximate dimensions were —Tonnage (b.o.m), 100 tons, length of keel, 68 ft.; breadth, extreme, 19 ft.; draught, mean, 8 ft Inv. 1907–61.

173. HALF MODEL OF H.M.S. "CRESSY." (Scale 1 : 48.) Presented by the Admiralty, 1920.

This two-decked line-of-battleship of 80-guns was designed as a sailing ship by Messrs. Read, Chatfield and Creuze, and was laid down at Chatham Yard in 1846. In 1852 she was ordered to be converted to a screw ship and was launched as such in 1853.

As a sailing ship her armament and dimensions would have been fourteen 8-in 65-cwt. guns, eighteen 32-pr 56-cwt guns, twenty-four 32-pr 50-cwt. guns, and twenty-four 32-pr 42-cwt guns

Tonnage, 2,538 tons, length, 198 4 ft., breadth, 55 ft., depth, 21·7 ft Complement, 750 men Inv. 1920–162.

174. LITHOGRAPH OF THE ALLIED FLEETS (1854).

This lithograph, after a painting by Louis le Breton, represents H.M.S "Banshee" bringing the news of the declaration of war on Russia on April 9th, 1854.

The British and French Fleets were anchored in Karvana Bay, Black Sea, and shortly after the declaration sailed for the Crimea

The principal vessels represented are —

Name.	Nationality.	Type	Guns	Built	Length	Breadth	Tonnage.
					ft	*ft*	*tons*
Banshee .	British	Paddle-Vessel		1848	189·0	27·2	654
Jena .	French	Sailing two-decker	90	1814	197·0	53·28	4,650
Jupiter ..	French	Sailing two-decker	86	1831	192·0	50·0	3,693
Bayard ..	French	Sailing two-decker	90	1847	197 0	51 67	3,998
Descartes ..	French	Paddle-Frigate		1844	230·1	40·68	2,978
Marengo .	French	Sailing two decker	82	1810	181·4	47 5	2,964
Ville de Paris	French	Sailing three-decker	120	1851	207 3	53·8	5,005
Le Valmy ..	French	Sailing three-decker	120	1847	210·0	57·0	5,154
Henry IV ..	French	Sailing two-decker	100	1829	204·3	53·1	4,374
Friedland .	French	Sailing three-decker	120	1840	207·3	53·8	5,005
Britannia ..	British	Sailing three-decker	120	1820	205·0	54·5	2,616
Rodney ..	British	Sailing two-decker	92	1833	205·5	54·5	2,626
Albion ..	British	Sailing two-decker	90	1842	204·0	60·2	3,111
Agamemnon	British	Screw two-decker	91	1849–53	230·0	55·5	3,102

Inv. 1921–1020.

175. LITHOGRAPH OF MORTAR BOATS IN ACTION.

This shows the early mortar boats "Firm," "Flamer," and "Hardy" engaging the Quarantine Battery, Sebastopol, on August 15th, 1855

At the outbreak of the Russian War, in 1854, a number of these small shallow-draught vessels were rapidly built by various shipbuilders in the United Kingdom, to the order of the British Admiralty, for operations against land batteries in the Baltic and Black Seas They each carried amidships a single 13-in mortar, weighing about 5 tons and throwing a 200 lb. shell, they were usually towed into action by steamers, but were cutter or yawl rigged for independent manœuvring if necessary

Their approximate dimensions were Tonnage (b o m), 100 tons; length, 60 ft, breadth, 20 ft, depth, 9·5 ft., draught, 3 ft Inv 1905 42

176. HALF MODEL OF H.M.S "BACCHANTE" (Scale 1 . 48) Presented by the Admiralty, 1920

This 50-gun frigate was designed by Messrs Read, Chatfield and Creuze, in 1849, to the following particulars

Tonnage, 2,006 tons, length, 187 3 ft, breadth, 50 5 ft, depth, 15 5 ft

The proposed armament consisted of —Main deck, twenty-eight 8-in 65-cwt guns, upper deck, twenty-two 32-pr 45-cwt guns; and the complement of 500 men

In consequence, however of the more general introduction of steam into the Navy, the keel of this vessel was never laid, and the material provided for her was used in the construction of a screw steam ship of the same name

Inv 1920-243

177. HALF MODEL OF H.M.S "SAN FIORENZO." (Scale 1 . 48) Presented by the Admiralty, 1920

This 50-gun frigate was designed by Messrs Read, Chatfield and Creuze She was laid down at Woolwich Yard in June, 1850, but was never built In consequence of the general introduction of steam, her frame was taken down in 1856 and the material used in the construction of some screw corvettes

The armament proposed consisted of Main deck, twenty-eight 8-in 65-cwt guns, upper deck, twenty-two 32-pr 45-cwt guns, and the complement of 500 men

Tonnage, 2,006 tons, length, 187 3 ft, breadth, 50 5 ft, depth, 15 5 ft

Inv 1920- 165

178. HALF MODEL OF H.M.S "SANS PAREIL" (Scale 1 . 48) Presented by the Admiralty, 1920.

This two-decked line-of-battleship of 84 guns was designed by Sir Wm Symonds on the lines of the "Sans Pareil," captured from the French in 1794 She was laid down at Devonport Yard in 1845 but she was not completed as a sailing ship In 1848 she was ordered to be converted to a screw ship, and was launched as such in 1851

Tonnage, 2,242 tons, length, 193 ft, breadth, 52 6 ft, depth, 22 , ft

The model and dimensions are as designed for a sailing ship, but another model representing the vessel as she was actually built is shown among the exhibits relating to steam-propelled ships-of-war Inv 1920-160 A

179. HALF MODEL OF H.M.S "HANNIBAL." (Scale 1 48.) Presented by the Admiralty, 1920

This two-decked line-of-battleship of 90 guns was designed as a sailing ship by Mr J. Edye, Assistant Surveyor of the Navy, and was laid down at Deptford Yard in 1848 Before completion she was lengthened and adapted for a screw ship by Mr Edye and was launched as such in 1854

The armament originally proposed was.—Lower deck, thirty-two 8-in 65-cwt guns, main deck, thirty-four 32-pr 56-cwt guns, upper deck twenty-four 32-pr 42-cwt guns

Tonnage, 2,966 tons, length, 208 ft, breadth, 58 ft.; depth, 24 ft., complement, 820 men

The model and the dimensions represent the vessel as originally designed, but a model of her as actually built is exhibited with representations of steam-propelled ships-of-war. Inv. 1920-159 A

180. HALF BLOCK MODEL OF H.M.S. "HOOD." (Scale 1 : 48.) Presented by the Admiralty, 1920.

This 80-gun two-decked line of battleship was designed as a sailing ship by the Admiralty and laid down in Chatham Yard in 1849. Before completion she was lengthened and adapted for screw propulsion, and was launched in 1859.

The model represents the vessel as designed for a sailing ship with the following dimensions :—Tonnage, 2,600 tons ; length, 198 ft ; breadth, 55·7 ft ; depth 23·3 ft. Inv 1920-167

MERCHANT SAILING VESSELS.

Until about the 16th century merchant sailing ships did not differ from the sailing ships of war, and even as late as the early part of the 19th century no very distinct separation can be made between these two classes of vessel, although at the earlier periods when Greece and Rome were most prosperous, the fighting and commercial fleets were, at at present, quite distinct.

Following the exploration of the 15th and 16th centuries and the resulting development of overseas trade, the East India Company was founded about 1600 and in later years this Company had a monopoly of British trade with the East and also acquired a fleet of vessels which were superior in construction and equipment to ordinary trading vessels. Though primarily merchantmen they carried an armament and often took part successfully in naval engagements.

For the trade with the West Indies, which was not subject to similar restriction, a type of vessel was developed which was more suitable for mercantile purposes and had in comparison more cargo capacity. Like the East Indiamen, these vessels followed conventional lines with bluff bows, but before the middle of the nineteenth century a new type known as a clipper was introduced in America, although the same name had previously been applied to a different class of vessel. The clipper now introduced had a much increased length in proportion to its breadth and a fine bow with a curved stem and a rounded stern, features which resulted in an increase in speed. During the period immediately following the repeal of the Navigation Laws in 1849, British shipping suffered considerably from the competition of the superior American vessels, but improved designs were introduced and vessels were built in England which could compete successfully with the new American type.

About this time the China tea trade played an important part in the development of ship design. Owing to the desire of different ship owners to get the new tea crops to London as soon as possible, there were a series of annual races, and until 1867 rewards were offered for the first vessels arriving in London. A lithograph showing the last phase of such a race in 1866 is included in the Collection (*see* No. **198**). In this case three vessels which started from Foo-chow-foo at the same time were out of sight of each other during the voyage until they reached the English Channel on the same day. They made the voyage in 99 days, but in 1869 the "Sir Lancelot," a composite ship, built by Messrs. R. Steele & Co., at Greenock in 1865, completed the voyage in 89 days. Other famous British clippers were the "Thermopylae," built at Aberdeen by Messrs. W. Hood & Co., for Messrs. G. Thompson & Co. in 1868, and the "Cutty Sark,"

built at Dumbarton by Messrs. Scott & Co. in 1869. Both were composite built, and under the name of the "Ferreira" the latter was in service as late as 1919.

The route followed by the China tea clippers was *via* the Cape of Good Hope, but after the opening of the Suez Canal in 1869, they were displaced by steamships using the shorter route.

After the general introduction of steam propulsion large sailing vessels continued in use for long voyages and were built upwards of 4,000 tons register, the requisite sail area being obtained by the use of from four to seven masts. Some of the modern sailers have been fitted with small auxiliary steam or motor power by which they can be economically driven through a district of calm at a speed of about six knots. Very few large sailing vessels have, however, been constructed in recent years.

Shipbuilding was for ages entirely empirical, and until the middle of the 19th century, it advanced very slowly both in design and construction, except during a portion of the 17th century. The material used for all the main parts was wood; and knees, breast-hooks, and pillars of iron were not introduced until about 1810.

The use of iron for the shell of a vessel was tried as early as 1787, by John Wilkinson, the ironmaster, but the practical introduction of iron shipbuilding dates from 1829, when John Laird, of Birkenhead, commenced its construction, although it may be mentioned that it was thirty years later before the Admiralty would adopt the idea for naval construction.

The substitution of iron for wood caused a saving in weight of about 35 per cent., while since about 1870, the introduction of mild steel has enabled a further reduction in scantlings by 15 per cent, so allowing a steel hull to be only about one-half the weight of a corresponding wooden one.

Owing to the fouling of iron vessels on long voyages and the consequent reduction of speed, many attempts were made at directly sheathing an iron ship with copper, etc, but owing to the resulting galvanic action, these had to be abandoned, and a composite system of construction introduced This system consisted of wood planking secured to the iron frames, the copper sheathing being nailed to the outside of the planks, this method providing a remedy against corrosion The first vessel of this type to be classed in Lloyd's Register was the "Tubal Cain," of 787 tons, built in 1851, but the famous China tea clippers were the most celebrated examples of this system of construction. This method, however, proved to be expensive, and is now practically abandoned

The classification and registration of vessels dates back to the time of the Phœnecians, the earliest merchants; the present insurance register has, however, developed from the "ships lists" prepared by the proprietor of Lloyd's Coffee House, about 1700. In 1834, a great expansion was effected, and Lloyd's Register of British and Foreign Shipping was established in its present form, and on an international basis.

181. WHOLE MODEL OF S. "REVENGE." (Scale 1/24.) Lent by A. S. Cope, Esq., R.A., 1914.

This contemporary model represents the Honourable East India Company's ship "Revenge," built for the Bombay Marine Fleet in 1754, by the Lowjee Company, a Parsee firm of shipbuilders at Bombay. She was built of teak, copper fastened throughout, and was classed as a frigate.

The crews of the East Indiamen exceeded trading requirements in numbers, and were trained similarly to men of the Royal Navy. These vessels performed the duties of both man-of-war and merchantman and often took part in actions against the French

The "Revenge" was last seen on April 20th, 1782, and is supposed to have been lost in the terrific gale then blowing.

The armament consisted of 28 guns—twenty 12-prs on the upper deck and eight 6-prs on the forecastle and quarter-deck. Her complement was 140 men.

Tonnage, 610 tons; length on keel, 109 ft., breadth, 33 ft; depth of hold, 12 ft. Inv 1914-740

182. HALF MODEL OF BRIG "LIBERTY AND PROPERTY." (Scale 1.48) Lent by James Young, Esq, 1883.

This sailing vessel was built of wood at Whitby in 1754 She was employed in the Shields and London coasting trade, but her ports and some other details suggest that she was intended for use as a war-vessel if required.

Tonnage, 274 tons, length, 120 ft, breadth, 28 ft, depth at side, 20 ft. Inv. 1883-42.

183. RIGGED MODEL OF BRIG "BROTHERLY LOVE" (Scale 1 96) Lent by James Young, Esq., 1876

This merchant sailing vessel was built of wood at Ipswich in 1764 and in 1876 was said to be still employed as a coasting collier Many of these small brigs were engaged in this coasting trade, until the general introduction of steam colliers rendered them almost obsolete

Gross register, 214 tons, length, 86 5 ft, breadth, 24 ft, depth at side, 27 ft. Inv 1876-1382

A photograph is also shown.

184. RIGGED MODEL OF BRIG "ANTELOPE." (Scale 1.96.) Lent by James Young, Esq., 1876

This vessel, built of wood at Sunderland in 1766, is shown with topsails, courses, driver, foretopmast staysail, and jib set.

Tonnage, 195 tons, length, 80 ft., breadth, 24 ft, depth at side, 20 ft. Inv 1876-1364.

185. OIL PAINTING OF S. "SWALLOW" Lent by the Peninsular and Oriental Steam Navigation Co, 1903

This shipbuilders' picture, painted in 1788 by T Luny, represents a ship of 18 guns and about 700 tons burden, belonging to the Hon East India Company.

The vessel is shown in three different positions—Bow view "Hove to" for picking up a pilot, Broadside view Under plain sail, Stern view Before the wind and under all possible sail Inv 1903-41, S M. 525.

186. LITHOGRAPH OF S. "THE EARL BALCARRAS."

This lithograph, by T G. Dutton, represents one of the latest and largest of the vessels belonging to the Hon. East India Company and known as "East Indiamen."

"The Earl Balcarras" was built at Bombay in 1815 and was sold out of the service in 1834 when the Company ceased their trading operations. She carried 130 men, twenty-six 18-pr. guns, and was of 1,417 tons burden. The vessel is here shown sailing "free"—under plain sail and weather studding-sails. Although carrying but one tier of guns she is painted to represent a two-decked man-of-war. Inv. 1909-97.

187. RIGGED MODEL OF EAST INDIAMAN. (Scale 1 : 48) Presented by Lieut. J. S Raynes, R.N., 1920.

This rigged model represents one of the fast sailing cargo and passenger vessels known as East Indiamen, plying between England and the East, during the early part of the 19th century

The Hon. East India Company's monopoly of this trade ceased in 1814 and their trade lapsed altogether in 1833, private firms buying up the old "John Company's" ships.

The model is pierced for 20 guns on the main deck and for 14 on the upper deck, at this time the arming of these ships was dying out, but for many years they still had ports and were fitted with eyebolts for the gun breechings and tackle if required

Tonnage (b o m), 830 tons, length on keel, 114 ft, breadth, 36·75 ft, depth of hold, 14 ft. Complement, 60 men Inv. 1920 408

188. RIGGED MODEL OF A BARQUE (1850). (Scale 1 · 48) Plate X, No 1, p. 58

This model was originally the property of the late W H Overend, marine artist (1851–1898), and represents a wood-built, barque-rigged sailing vessel of about the middle of the 19th century The model was re-rigged in the Museum in 1909

The barque rig differs from the ship rig in having the sails on the mizzen-mast fitted in a fore-and-aft direction, instead of being carried transversely on yards It was much in vogue in merchant craft of the 14th and 15th centuries, but afterwards fell into disuse, until it was revived about the middle of the 19th century As fewer hands are required to manage the sails, this form of rig reduces to some extent the working expenses of a vessel, and it is now largely adopted both by steamers and sailing vessels It may be noted that on recent vessels there has been a tendency to use relatively shorter masts and longer yards to obtain the necessary sail area

Gross register, 960 tons, length, 170 ft, breadth, 32 5 ft Inv 1908-43, S M 188

189. RIGGED MODEL OF EARLY CHINA CLIPPER (Scale 1 · 48) Presented by L P C Phillips, Esq, 1911 Rigged in the Museum from particulars supplied by Messrs A Hall & Co, Aberdeen Plate X, No 2, p 58

This model represents an early clipper ship, probably designed for the China and East India trade about 1850

She shows a top-gallant forecastle and a full poop, rounded at the sides Details of deck and side planking are given and also the positions of upper deck gun-ports for the use of light armament

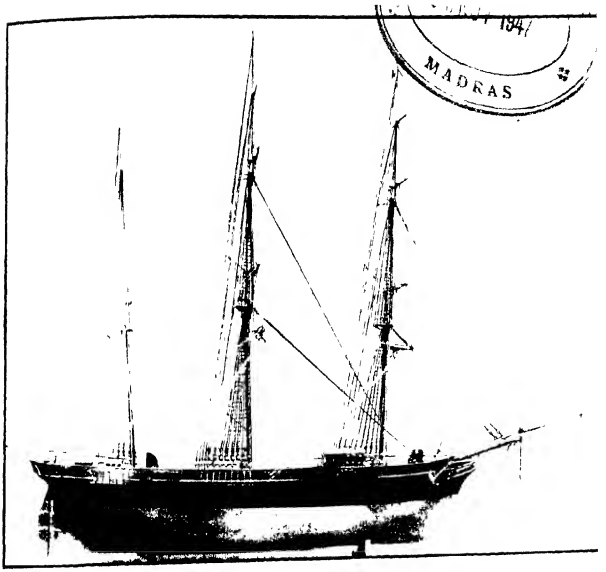
The hull of the model bears a general resemblance to that of the S "Stornoway," built of wood at Aberdeen in 1850 by Messrs A Hall & Co for Messrs Jardine, Matheson & Co, the particulars of the masts and spars of that vessel have been used in rigging the model The "Stornoway" was the first typical "clipper" engaged in the China tea trade She made the quickest passages of the year 1851 out and home, *i e*, in 102 and 103 days respectively, between the Downs and Hong-Kong She was diverted to the Australian trade after 1861 and, subsequently to the opening of the Suez Canal in 1869, was employed between London and Mediterranean ports She was wrecked in 1873

Her principal dimensions were.—Gross register, 595 tons, length, 157 8 ft, breadth, 25·8 ft, depth, 17·8 ft Inv 1911 112, S M. 614

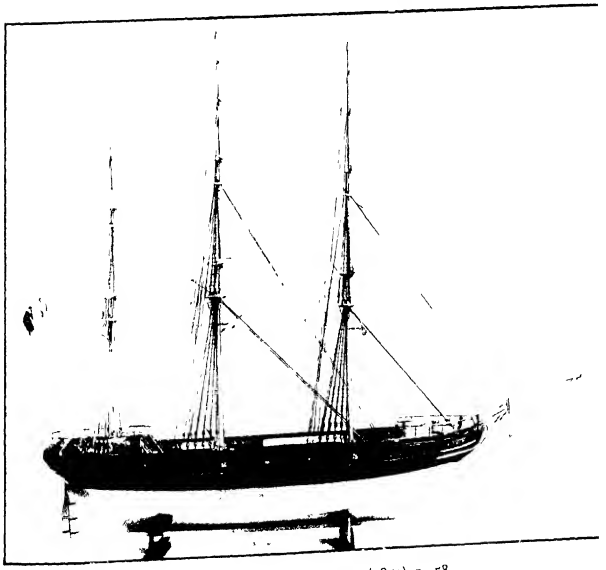
190. RIGGED MODEL OF S. "MERLIN" (Scale 1 . 96) Presented by H Davis, Esq., 1901

This is a built model of a wooden ship constructed at St John, New Brunswick, in 1851 and a sister ship to the "Eagle"—a well known clipper ship of the period They were both originally intended for sailing between Liverpool and New Orleans, but afterwards made voyages between England, Australia and the East and West Indies. Such vessels have now almost disappeared being replaced by the "tramp" steamer which, not confining itself to any route, goes wherever cargo is to be conveyed or procured.

Gross register, 1,030 tons, length, 176 ft; breadth, 40 ft, depth, 24 ft Inv. 1901–73, S.M 315.



No 1. Barque (1850), p 58



No. 2. Early China Clipper (1850) p. 58.

191. HALF BLOCK MODEL OF S. "FIERY CROSS" (1855). (Scale 1 : 48.) Lent by J. Campbell, Esq., 1869.

This wooden-built clipper ship was constructed by Messrs Rennie and Rankine at Liverpool in 1855 for the Liverpool and China trade She was built partly of fir, and was sheathed with yellow metal below the water-line.

Tonnage (b.o.m), 810 tons, register, 686, length, 173 ft ; breadth, 31·5 ft, depth, 18·75 ft. Inv 1869-11

192. WHOLE MODEL OF S "FIERY CROSS" (1860) (Scale 1 48.) Lent by J. Campbell, Esq., 1869

This clipper sailing ship, designed by Mr. Rennie, was built of wood and sheathed with yellow metal by Messrs Chaloner, Hart & Co, at Liverpool in 1860, for the China tea trade

She was considered to be an improvement on the American clippers, and to possess a more graceful appearance She was of relatively small beam with much less sheer and freeboard The "Fiery Cross" took part in several contests with other notable clippers on the voyages from China, one of her best performances being a voyage of 101 days from Foo-chow in 1861

Her leading particulars were :—Displacement at load water line, 1,615 8 tons, displacement per inch at water line, 10·46 tons, register tonnage, 702 tons (o m 863), length (b p), 185 ft, length on load line 181 ft, breadth, 31 25 ft, depth in hold, 19·5 ft, area of mid-section below load water line, 424 sq ft, area of load water plane, 4,395 sq ft Inv 1869-21, S M 1410

193. LITHOGRAPH OF S "MALABAR"

This full-rigged clipper ship, here represented under all plain sail, close hauled on the port tack, was built of wood at Sunderland, in 1863, by Mr Wm Pile, for Mr Richard Green, for the East Indian trade She was copper fastened, and her bottom was sheathed with felt and yellow metal

Tonnage, 1,350 tons, length, 207 2 ft, breadth, 36 6 ft, depth, 22 5 ft Inv 1905-165

194. HALF BLOCK MODEL OF CENTRE-BOARD SCHOONER (Scale 1 24) Presented by the Kew Museum of Economic Botany, 1876

This vessel was built about 1860 at Victoria, British Columbia, for the coasting trade

Displacement, 40 tons, length between perps, 51 ft, breadth, 15 ft, depth, 5 ft, draught, 3 5 ft Inv 1876-1355

195. RIGGED MODEL OF BENGAL PILOT BRIG (Scale 1 48)

This represents some six similar brigs built of iron in this country from the designs of Mr J Thompson between 1850 and 1870 for the pilot service at the mouth of the river Hooghly, Bengal This day and night service was carried on by three brigs, one brig cruised at or near the Western Channel of the Hooghly to supply pilots to ships inward-bound to Calcutta another was stationed near the Eastern Channel to receive the pilots leaving outward-bound ships, while the third brig conveyed pilots between the Eastern and the Western Channels, a distance of about 50 miles

These vessels were fast, easily-manœuvred craft with excellent sea-going qualities A large windlass, shown forward, was provided for use with coir hawsers

Gross register, 250 tons; length (b p), 105 ft, breadth, 25 ft

Steam vessels are now employed for this work Inv 1908-42, S M 27.

196. HALF BLOCK MODEL OF S "VICTORY" (Scale 1 48.) Presented by Messrs Laurence Hill & Co, 1865

This wooden sailing ship was built at Port Glasgow in 1863 by Messrs Hill & Co. for the Australian trade, on her first voyage she ran from the Clyde to New Zealand in seventy-two days

Gross register, 1,199 tons, length, 205 ft., breadth, 36 ft, depth, 22·9 ft Inv 1865-15

197. WHOLE MODEL OF S. "ARUNDEL CASTLE." (Scale 1 : 48.) Lent by Messrs. Donald Currie & Co., 1878.

This iron sailing ship was built at Greenock in 1864 for the London and Cape trade. She was ship-rigged, had two decks, and a poop deck 30 ft. long Register, 1,042 tons; length, 203 ft.; breadth, 33·5 ft.; depth, 21·9 ft
Inv. 1878–107, S.M. 1658

198. LITHOGRAPH OF CLIPPER RACE (1866).

During the years 1855–70, considerable rivalry existed between ship-owners engaged in the China tea trade, rewards were offered for the first vessels arriving in London with the early teas, and as a result great improvements were made in the building, equipping, and sailing of the ships employed Their route lay *via* the Cape of Good Hope, but since the opening of the Suez Canal, in 1869, they have been gradually displaced by steamships using the shorter route The composite system of construction, illustrated by drawings and models in an adjacent gallery, was largely adopted in this class of vessel

This lithograph shows the last phase of a race that excited unusual interest in shipping circles in 1866 Three vessels, "Ariel" (composite), "Taeping" (composite), "Serica" (wood), all built by Messrs R Steele & Co., at Greenock and each accredited with fast homeward passages, had started from Foo-chow-foo (China) practically together, and after losing sight of each other during the whole voyage reached the English Channel on the same day, each making a record passage of 99 days This record was reduced to 80 days by subsequent vessels The leading clippers, "Ariel" and "Taeping," are shown carrying stay-sails, sky-sails, studding-sails and mizzen courses The "Fiery Cross" (*see* No. 192) also took part in this race and completed the passage in 101 days

"Taeping" (1863), tonnage (b m), 707 tons, length, 183·7 ft ; breadth, 31·1 ft , depth, 19·6 ft

"Ariel" (1865), tonnage (b m), 853 tons, length, 197 4 ft ; breadth, 33·9 ft , depth, 19·6 ft
Inv 1905 25, 31,186

199. HALF BLOCK MODEL OF SCHOONER "JAMES DUCKETT" (Scale 1 · 30) Lent by Messrs Thomas Grendon & Co., 1888

This three-masted schooner was built of iron at Drogheda in 1865.

Register tonnage, 232 tons, length, 120·3 ft , breadth, 23 ft , depth at side, 12·75 ft
Inv 1888 240

200. RIGGED MODEL OF S "CARMARTHENSHIRE" (Scale 1 : 96)

This represents a ship-rigged vessel built at Pembroke Dock in 1865, she was of wood construction with iron beams

Double topsail yards and studding sail booms are shown on the model

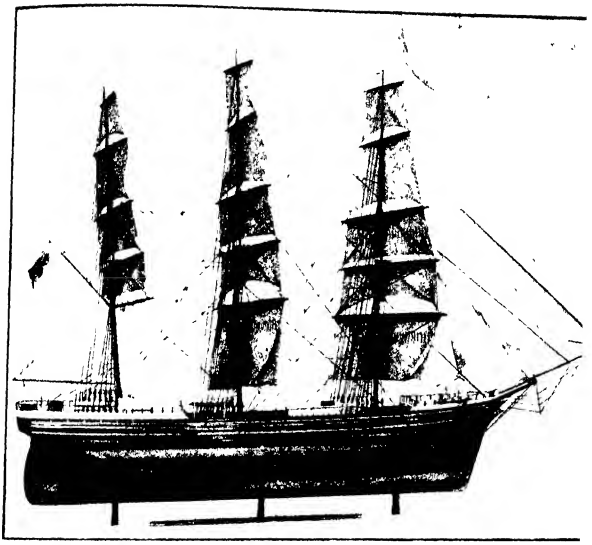
The principal dimensions of the vessel were :—Net register tonnage, 812 tons length, 174 6 ft , breadth, 32 7 ft , depth, 20·5 ft She was omitted from Lloyd's Registers after 1884
Inv 1910–107, S.M. 224

201. RIGGED MODEL OF S. "STONEHOUSE" (Scale 1 : 48.) Plate XI, No 1, p 60

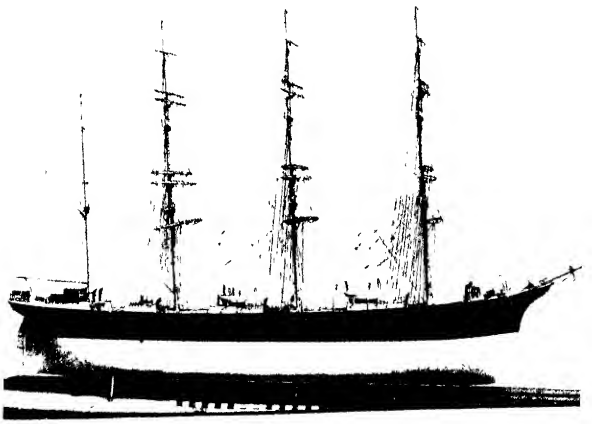
This wooden-built clipper sailing vessel was designed in 1863–64 by Mr Gilbert Row and built at Pallion in 1866 by Mr John Smurthwaite, for the Australian trade. She had a topgallant forecastle 43 ft long, and a full poop 66 ft long, where there was cabin accommodation for about 40 first-class passengers; she had also large cargo carrying capacity The vessel had double topsails and was sheathed with yellow metal and copper fastened, in service she proved herself to be one of the fastest ships of her day In 1875 she was transferred to French owners and re-named "Fanny."

The model was made by Mr Row in 1871, the starboard side shows the horizontal section lines, and the port side the vertical longitudinal ones. The masting, rigging, and sails were added in the Museum in 1906 A complete sheer draught or line drawing of this vessel is also shown

Gross register tonnage, 1,153 tons; length, 209 ft ; breadth, 36·2 ft , depth, 21·9 ft
Inv 1877–426, 30,894



No. 1. S "Stonehouse" (1863-66), p 60.



No 2. S. "California" (1890), p. 63.

202. WHOLE MODEL OF S. "DURHAM." (Scale 1 : 48.) Lent by Messrs. Oswald & Co., 1867.

This sailing ship was built of iron at Sunderland in 1866
Displacement at load line, 1,378 tons; register, 998 tons; length, 209·5 ft; breadth, 34·75 ft; depth, moulded, 21·3 ft Inv. 1867-7.

203. S "TITANIA" (1866). (Scale 1 : 48.) Lent by J. Steele, Esq., 1922.

This represents a famous composite-built clipper constructed in 1866 by Messrs Robert Steele & Co, for Messrs Shaw, Lowther & Maxton, London She was engaged in the China tea trade, and in 1871 completed the journey from Foo-chow to London in 93 days, which was the quickest passage of that year
Her principal dimensions were —Register, 879 tons (o.m 1,223 tons), length, 200 ft, breadth, 36 ft, depth, 21 ft Inv. 1922-640.

204. LITHOGRAPH OF S. "LAHLOO" (1867).

This lithograph by T G Dutton represents one of the fastest of the famous China tea clippers, she is shown outward bound and preparing to land her pilot Her quickest passage from Foo-chow-foo to London was 97 days in October-January, 1870-71. She was wrecked in 1872
The vessel was of composite construction and was built by Messrs Steele & Co., Greenock, in 1867
Her principal dimensions were - Register 799 tons, length, 191·6 ft; breadth, 32·9 ft, depth, 19 9 ft Inv. 1910-200.

205. RIGGED MODEL OF CLIPPER SCHOONER "JOHN WESLEY" (Scale 1 32)

This schooner-rigged clipper, of composite construction, was built at Aberdeen in 1807 by Messrs Hall & Sons, for the London and Australian trade In 1873 she was brig-rigged and passed into the employ of the Wesleyan Missionary Society, with whom she remained until 1881, when she again became a trading vessel The model was rigged in the Museum in 1910 from particulars supplied by Messrs Hall, Alexander & Co, and shows the vessel as originally fitted out
Like all composite-built vessels her principal internal framing was of iron, her outside planking was partly of American elm and partly teak, it was also copper-fastened and sheathed with yellow metal below the water-line There were two decks, with a raised quarter-deck 35 ft long, which were mainly planked with yellow pine
Her principal dimensions are —Register tonnage, 238 tons, length, 118 ft.; breadth, 23 6 ft, depth, 13 5 ft Inv 1908-50, S.M. 180.

206. WHOLE MODEL OF S "CYGNET" (Scale 1 : 48.) Lent by A T Rowe, Esq., 1870.

This represents a wooden sailing ship on launching ways. The starboard side shows the framing and disposition of the timbers, the port side the planking Her poop was 40 ft, and forecastle 28 ft in length, in addition she was provided with a deck-house, 24 ft long by 12 ft broad
Tonnage (b o m), 446 tons, length, 144 ft, breadth, 26 ft.; depth, 12 ft Inv 1870-9, S M 1659

207. HALF BLOCK MODEL OF CLIPPER SHIP (Scale 1 48) Lent by J Campbell, Esq., 1869

This represents a British sailing clipper of the following dimensions.— Length, 170 ft; breadth, 28 ft.; depth, 21 ft Inv 1869-12

208. RIGGED MODEL OF AMERICAN SCHOONER "E. W. MORRISON" (Scale 1 : 24.) Presented by Phillips Melville, Esq., 1909.

This represents a wood-built three-masted fore-and-aft schooner which was employed, about 1870, in the transport trade on the North American

lakes. She belonged to the port of Chicago and had the following approximate dimensions: Length, b.p., 85 ft., breadth, 22 ft.; register tonnage, 150 tons.

Vessels of the "schooner" rig carry all their sails in a fore-and-aft direction or if of the "topsail schooner" class carry, in addition, yards and upper square sails on the foremast. Fore-and-aft schooners have been largely developed in the coasting and lake trades of North America since about 1860; they are well adapted for use in smooth water with off-shore winds and require a comparatively small crew to manage them. Their usual characteristics are, high bow, full beam, wide quarters and tall lower masts. They are principally engaged in coal, lumber, ice and fish transport, and sometimes make oversea voyages. Later examples of this type of sea-going American sailing vessel show a remarkable increase in size, they are over 300 ft in length, 3,000 to 5,000 register tons and carry six to seven masts Inv 1909-103, S M 1831

209. HALF BLOCK MODEL OF SCHOONER "SAINT" (Scale 1 : 36.) Lent by Messrs Thomas Grendon & Co, 1888

Thus three-masted schooner was built of wood at Drogheda in 18,0

Gross register, 118·12 tons, carrying capacity, 204 tons, length (b p), 87·16 ft, breadth, 21 25 ft, depth at side, 10·0 ft Inv 1888 239

210. RIGGED MODEL OF SAILING SHIP (1870) (Scale 1 : 288) Made and presented by Capt Sir D Wilson-Barker, R N R, 1920

This model represents a ship-rigged British merchant vessel of about 1870 with double topsails

Approximate principal dimensions - Length (over all), 168 ft, breadth, 28 ft., depth, 21 ft Inv 1920 142

211. HALF BLOCK MODEL OF Ss "LAMMERMOOR" AND "CEDRIC THE SAXON" (Scale 1 48) Lent by Messrs John Reid & Co., 1881

These full-rigged sailing ships were built of iron at Glasgow in 1874 75

Register, 1,704 tons, length, 249 5 ft, breadth 40 ft, depth, 23 6 ft Inv 1881 29.

212. HALF MODEL OF S "JAPANESE" (Scale 1 48) Lent by T Royden, Esq., 1876

This represents a wooden sailing vessel, for both passenger and cargo service The poop is 48 ft long and the forecastle 38 3 ft

Gross register, 905 tons, length, extreme, 193 ft, breadth, 29 ft, depth, 20 ft. Inv 1870-1366

213. HALF BLOCK MODEL OF S "COUNTY OF SELKIRK" (Scale 1 48) Lent by Messrs. Barclay, Curle & Co, 1881

This four-masted sailing ship was built of iron at Glasgow in 1878 for the "Counties" East Indian line

Register, 1,942 tons, length, 281 ft, breadth, 40·5 ft, depth, 24 ft Inv 1881 36

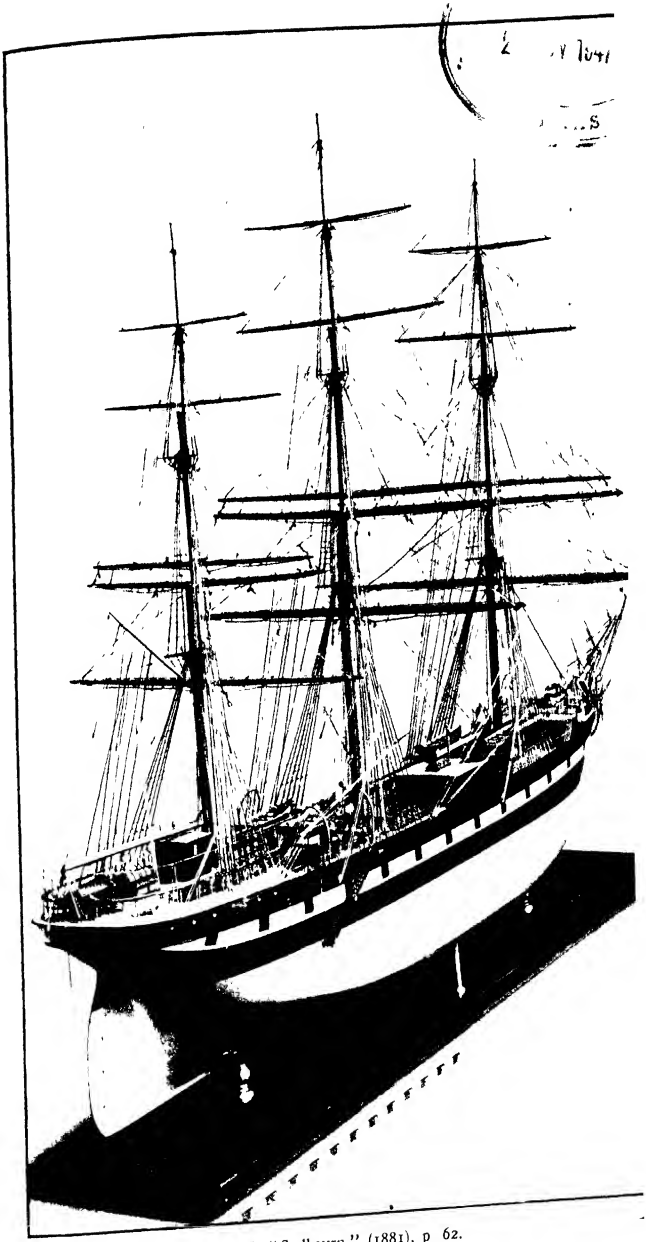
214. RIGGED MODEL OF SAILING SHIP (1880) (Scale 1 : 432) Made and presented by Capt Sir D Wilson-Barker, R N R., 1920

This small model represents a fully ship-rigged British merchant vessel with double topsail and double topgallant yards on all masts

Approximate principal dimensions —Length (overall), 252 ft, breadth, 39 ft, depth, 25 ft Inv 1920–143.

215. RIGGED MODEL OF S "SUDBOURN." (Scale 1 : 48.) Lent by Messrs. Richardson, Duck & Co., 1896. Plate XII, p. 62.

This full-rigged sailing ship was built of iron at Stockton-on-Tees in 1881.



S. "Sudbourn" (1881), p 62.

She has two steel decks; her poop is 42 ft. and forecastle 33 ft. long Her bar keel is 9·5 in deep, and she has one collision bulkhead

Gross register, 1,750 tons; net register, 1,700 tons; length, 265 ft , breadth, 39 ft , depth, 24·25 ft. Inv. 1896–101, S M 1058, S M 1059

216. HALF BLOCK MODEL OF S. "PALGRAVE" (Scale 1 . 64.) Lent by Messrs Wm. Hamilton & Co., 1884

This four-masted sailing ship was built of iron at Glasgow in 1884 When launched she was the largest sailing ship afloat Her masts and lower yards are of steel, and she is fitted with a donkey boiler to supply steam to the engines of the cranes, winches, pumps, etc

Register, 3,111 tons , length, 309 5 ft , breadth, 48 ft , depth of hold, 25·6 ft Inv 1884-175

217. HALF BLOCK MODEL OF S. "FALLS OF EARN" (Scale 1 · 48) Lent by Messrs. Russell & Co , 1888

This four-masted sailing ship was built of iron at Greenock in 1884 She had three tiers of beams, two decks, and one bulkhead She was fitted with steam appliances for the general heavy work of the vessel

Gross register, 2,386 tons , length, 300 ft.; breadth, 42 ft , depth, 24 5 ft Inv 1888-247

218. HALF BLOCK MODEL OF BARQUE "MAIDEN CITY" (Scale 1 48) Lent by Charles J Bigger, Esq , 1888

This barque was built of steel at Londonderry in 1887

Gross register, 1,242 tons , dead weight capacity, 1,950 tons , length, 223 25 ft , breadth, 35 ft., depth, 20 6 ft Inv 1888-244

219. HALF BLOCK MODEL OF BARQUE "CUPICA" (Scale 1 48) Lent by Charles J Bigger, Esq , 1888

This barque was built of steel at Londonderry in 1888, and has two decks and one bulkhead

Gross register, 1,210 tons , dead-weight capacity, 1,650 tons , length, 226 ft , breadth, 36·4 ft , depth, 21·9 ft Inv 1888-245

220. PHOTOGRAVURE OF BARQUE "FRANCE" Presented by Messrs D and W Henderson & Co , 1891

This five-masted, barque-rigged sailing vessel was built of steel at Glasgow in 1890 by Messrs Henderson & Co for the French mercantile marine

Gross register, 3,784 tons , dead weight of cargo, 6,150 tons , length, 361 ft , breadth, 48 8 ft , depth, 25·9 ft , water ballast capacity, 2,200 tons Inv. 1891-112

221. RIGGED MODEL OF S "CALIFORNIA" (Scale 1 . 48) Lent by the Oceanic Steam Navigation Co , 1914. Plate XI, No 2, p 60

This four masted barque-rigged vessel represents the last and the largest of the White Star sailing clippers She was of steel construction and was built and equipped at Belfast in 1899 by Messrs Harland & Wolff for the North Western Shipping Co (Messrs Ismay, Imrie & Co)

She has two complete decks with a lower tier of deck beams Double topsail and top-gallant-sail yards are carried on three of the masts.

In 1890 the vessel passed to German owners, was re-named "Alster," and became name-ship of the Alster line of sailing ships belonging to Hamburg , another change of name and ownership took place in 1912

Lloyds particulars of the vessel are —Gross register, 3,099 tons , length, 329 3 ft , breadth, 45·2 ft Inv. 1914-310, S M 1661

222. RIGGED MODEL OF BARQUE "PASS OF MELFORT" (Scale 1 48) Lent by the Fairfield Shipbuilding and Engineering Co , 1896

This four-masted barque-rigged sailing vessel was built of steel at Glasgow in 1891. She has one deck of steel, sheathed with wood , her poop is 50 ft. long,

forecastle 42 ft, and her bar keel is 10·5 in. deep. The lower and topmasts are in one, and she has double topsail and topgallant yards. Steam power is used for the heavy work of the ship.

Gross register, 2,346 tons; net, 2,195 tons; dead weight cargo, 3,850 tons, length, 298·7 ft.; breadth, 44 ft; depth, 24·5 ft. Inv. 1896–100, 31,085

223. HALF MODEL OF S. "DONNA JULIA." (Scale 1 : 48) Presented by James Hayes, Esq., 1912.

This is the half-block model of a three-masted sailing barque, built of steel at Greenock in 1892 by Messrs. Russell & Co., for Messrs J. Hayes & Co She was lost at sea about 1899.

She had one complete deck and two tiers of transverse beams

Gross register, 1,432 tons; length, 236·7 ft; breadth, 36·1 ft.; depth, 21·7 ft Inv 1912-96

224. PHOTOGRAPH OF S. "DONNA FRANCISCA." Presented by James Hayes, Esq., 1912.

This four-masted sailing barque was built of steel at Greenock in 1892 by Messrs Russell & Co.

There is one complete deck and two tiers of beams No cellular double-bottom is fitted but two large tank holds are provided for carrying 1,020 tons of water-ballast which enable the vessel to sail safely with little or no cargo These tanks can be used for cargo if necessary

Dimensions (Lloyds) —Gross register, 2,277 tons, length, 277 5 ft, breadth, 42 ft, depth, 24 5 ft

This vessel passed under the German flag in 1910 and was re-named "Herbert" Inv 1912-97

225. PHOTOGRAPH OF S "MARIA RICKMERS." Presented by James Hayes, Esq, 1912.

This five-masted sailing barque was built of steel at Port Glasgow in 1892 by Messrs Russell & Co for German owners She had two complete decks with web-framing below. Water-ballast, to the extent of 1,236 tons, could be carried in the main tank and double-bottoms.

She was fitted with auxiliary propelling engines of three-stage expansion type made by Messrs. Kincaid & Co, Gourock, having cylinders 16 in, 26 in, 42 in diam. and 27 in. stroke, developing 750 i h p

Dimensions (Lloyds) —Gross register, 3,822 tons, length, 375 7 ft, breadth, 48·0 ft.; depth 25 4 ft

This vessel was lost on her first voyage—July, 1892 Inv 1912-99

226. PHOTOGRAPH OF S. "BERMUDA." Presented by James Hayes, Esq, 1912

This four-masted sailing barque was built of steel at Greenock in 1893 by Messrs. Russell & Co for Messrs P Denniston & Co. There is an awning deck and a main deck with three tiers of beams Water ballast to the extent of 1,340 tons may be carried in a large tank hold amidships, this has some advantage over double-bottom ballast spaces when a vessel is in light condition, the tank hold may also be used for cargo when convement

Dimensions (Lloyds).—Gross register, 2,846 tons, length, 280·2 ft.; breadth, 44·5 ft, depth, 22·9 ft Inv. 1912-100.

227. PHOTOGRAPH OF S. "DUNEARN." Presented by James Hayes, Esq., 1912.

This three-masted sailing barque was built of steel at Port Glasgow in 1894 by Messrs. Russell & Co. for Messrs J Dunn & Co. She had one complete deck and two tiers of beams

Dimensions (Lloyds).—Gross register, 1,632 tons; length, 245·2 ft., breadth, 37·5 ft.; depth, 22·6 ft.

In 1909 this vessel passed to Norwegian owners and in 1910 was lost at sea.

A framed "displacement scale" of the "Dunearn," indicating free-board in relation to draught and displacement, is also shown Inv. 1912-98

STRUCTURAL MODELS (Merchant Sailing Vessels).

The following small group of models and a drawing represent the general features of wood and composite construction in merchant sailing ships, but in addition there is, in another section of the Collections, a series of models showing the more important details of ship construction and design.

228. MODELS ILLUSTRATING WOODEN SHIP CONSTRUCTION. (Scales 1 : 48 and 1 : 24 respectively.) Lent by T. Royden, Esq., 1876.

The first model represents the framing of a three-masted wooden ship, with the square stern common at the beginning of the 19th century The second shows a single-masted vessel In both cases the frames are widely spaced and built up of two thicknesses of timber. Inv 1876–1389

229. HALF MODEL OF DIAGONALLY SHEATHED VESSEL. (Scale 1 : 48.) Lent by Lloyd's Register of Shipping, 1876.

This shows a wooden merchant vessel, sheathed with planking laid diagonally at about 45° in one direction at the bow, and with the opposite inclination at the stern, the intermediate triangular space being planked vertically Inv 1876–1396

230. BUILT MODELS SHOWING WOODEN SHIP CONSTRUCTION. (Scale 1 48) Lent by Lloyd's Register of Shipping, 1876

The fore and after bodies of a merchant ship are shown, on the port side the inner and outer planking is complete, while on the starboard side the frames are visible, being held together by temporary ribbands, as during construction. Some of the hanging iron knees are extended to the deck beams below them Inv 1876–1393

231. MODEL SHOWING LONGITUDINAL SECTION OF WOODEN MERCHANT SHIP. (Scale 1 : 32) Lent by Lloyd's Register of Shipping, 1876

This is a longitudinal section of a square-sterned wooden merchant ship, and has the leading details distinctly labelled. It represents the later form of wooden construction, in which the knees and most of the pillars are of iron. The lower beams are not decked over, except at the fore end, as they are only introduced to strengthen the hull Inv 1876–1392.

232. DRAWING OF COMPOSITE BUILT SHIP. (Scale 1 24) Lent by Lloyd's Register of Shipping, 1876

This represents a three-masted sailing vessel of about 1,000 tons register, built to conform with Lloyd's rules of 1866 for composite vessels

The transverse frames are of angle and reverse angle-bars, riveted together, outside these is riveted an iron sheer-strake 1 in in breadth for every 6 ft of the vessel's length, and a bilge-strake two-thirds of the breadth of the sheer-strake, the butts of both these strakes are connected by butt-straps between frames Riveted to the frames between the strakes are diagonal ties or riders, making a structure resembling a diagonal truss. The planking is bolted to these ties and frame angles, the butts coming midway between adjacent frames, on plates riveted to them. Inv 1876–1465

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